

# International Geology Review

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## INTERNATIONAL GEOLOGY REVIEW

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IGR transliteration of Russian<sup>(1)</sup>

The AGI Translation Center has adopted the essential features of Cyrillic Transliteration recommended by the U. S. Department of the Interior, Board of Geographical Names, Washington, D. C.

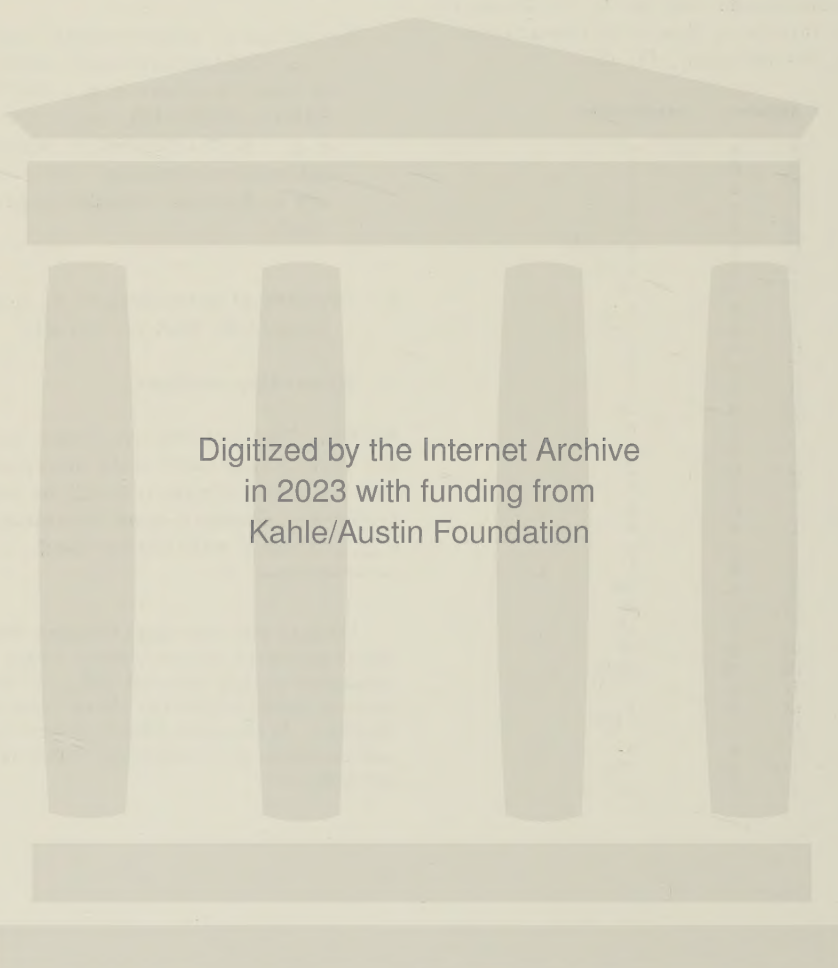
Alphabet		transliteration
А	а	a
Б	б	b
В	в	v
Г	г	g
Д	д	d
Е	е	e, ye <sup>(1)</sup>
Ё	ё	ë, yë
Ж	ж	zh
З	з	z
И	и	i <sup>(2)</sup>
Й	й	y
К	к	k
Л	л	l
М	м	m
Н	н	n
О	о	o
П	п	p
Р	р	r
С	с	s
Т	т	t
У	у	u
Ф	ф	f
Х	х	kh
Ц	ц	ts
Ч	ч	ch
Ш	ш	sh
Щ	щ	shch
Ъ	ъ	" <sup>(3)</sup>
Ы	ы	y
Ь	ь	' <sup>(3)</sup>
Э	э	e
Ю	ю	yu
Я	я	ya

However, the AGI Translation Center recommends the following Modifications:

1. Ye initially, after vowels, and after . Customary usage calls for "ie" in many names, e.g., SOVIE KIEV, DNEPER, etc.; or "ye", e.g., BYELORUSSIA, where "e" follows consonants. "e" with dieresis in Russian should be given as "yo".
2. Omitted if preceding a y, e.g., Arkhangelsky (not iy; not ii).
3. Generally omitted.

NOTE: The well-known place and personnel names that have wide acceptance in international literature will be here adopted. However, German-type transliteration e.g., J for Y will not be used.

<sup>1</sup> Due to the individual training and tastes of the translators and reviewers whose work is published in this issue of IGR., it has been impossible to follow the above recommended system. In the near future, however, an effort will be made to standardize transliteration procedures.



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# TYPES OF FOLDING AND THEIR ORIGIN<sup>(1)</sup>

by

V. V. Belousov<sup>(2)</sup>

## ABSTRACT

It would seem that the data available today leave no room for doubt that all types of folding are to be regarded as phenomena arising from the vertical oscillations of the Earth's crust. The most difficult aspect of this conception is to explain the process that leads to the transformation of vertical movements into crumpling. With a view toward clearing up this question, special structural investigations have been undertaken. The principal results may be summed up as follows:

Of great importance in folding is the fact that during vertical movements, the Earth's crust often splits up into separate blocks which undergo differential vertical displacement. Folding is the reaction of stratified plastic rocks to differential vertical movements of blocks. There are three types of folding to be distinguished on the kinematic basis: block-folding, folding or injection, and folding of general crumpling.

Block-folding is the most direct reflection of the differential movements of the blocks comprising the Earth's crust. Box-folds are the most characteristic forms.

A further complication exists in the appearance and intensification of the horizontal movements of rock masses. When this involves not all layers but concentrates in the most plastic formation, folding of injection originates, in combination with a flow of plastic material from some places and its accumulation in others. The main cause of this type of folding is reflected in the horizontal flow of the plastic material under the effect of unequally distributed weight of the overlying beds. Relief of the Earth's surface, difference in the specific gravity of the plastic material and the overlying beds, and the extrusion of material from arches during uplift are secondary causes.

A prerequisite for folding of general crumpling is horizontal compressive stress in the crust. The causes of such stresses are considerably more local in character than is usually assumed. The compression

may be a result of: (a) Gravitational slipping aside of the upper part of an elevated block and its pressure on the neighboring lower blocks; (b) The squeezing out of material of the upper part of the elevated block because of the resistance of overlying rocks; (c) Free gravitational sliding (d) A succession of layers stretching and compressing, during successive differential elevations and subsidences of blocks.

All the various types of folding have a common basis in the differential vertical movements of the blocks of the crust. The occurrence of the most intensive folds in geosynclines thus becomes understandable. Different origins of folding make a geologist face the necessity of discovering local causes of folding in each folded region.

The origin of folding in the stratified masses of the earth's crust is still one of the most acute unsolved problems of geotectonics. It is well known that the first scientific attempts to solve this problem occurred in the classic period with the development of the contraction hypothesis. Most important during this period were the works of Suess /45/, Heim /33/, and Willis /46/. Even in later years when the dominant position of the contraction hypothesis had in large measure been lost, the problem of folding continued to be elaborated along similar lines. The researches of Heim /32/, already quoted, Sonder /43/,

<sup>1</sup>An original paper submitted for publication in International Geology Review by Dr. Belousov.

<sup>2</sup>Correspondent Member of the USSR Academy of Sciences; Institute of Physics of the Earth, Moscow.

Stille /44/, and Kober /34/, may be mentioned here. Some of the concepts of the contraction hypothesis as applied to folding are still being worked on at the present time, both in this country and abroad /15, 27, 35, 36, 41/. The studies of authors who uphold other hypotheses about the general development of the earth, but who retain the concept of a general contraction of the earth's surface to explain folding (e.g. de la Beche /26/), also belong in this category.

However, beginning with the first decade of this century, a number of authors (and this number gradually increased) pointed to characteristic peculiarities in the structure and history of the development of folded regions that contradict the connection of folding with a general horizontal compression of the earth's crust. These authors regarded horizontal compression as necessary to explain at least certain types of folding as local and secondary phenomena derived from other processes.

In this connection, we must first of all point to the work of the remarkable Austrian geologist Ampferer. This work has retained its significance to this day, fifty years from the time it appeared /24/. Ampferer's underlying principle was that the horizontal compression that causes folding in geosynclines arises within the geosynclines themselves and is in no way connected with the pressure of surrounding platforms on the geosyncline. Ampferer associated such local compression of the earth's crust with the reaction of the latter to subcrustal currents of magmatic masses. Subsequently, the idea of the fundamental role of subcrustal currents, chiefly convective in origin, in the development of the earth's crust was greatly developed, especially in the geophysical trend. As applied to folding, this idea has, of late, been most specifically elaborated by Griggs /29/. At the same time another trend was developing. Its adherents regarded those stresses that arise in the earth's crust during vertical wave-form oscillating movements as the cause of crumpling of layers into folds (a local phenomenon).

During the past twenty years the greatest success has been enjoyed by the hypothesis of gravitational folding. This

associates crumpling of layers with sliding along slopes of tectonic uplifts as a result of the force of gravity. The hypothesis, originally advanced by Reyer /40/ but left unnoticed at the time, was revived by Haarmann /30/ and was particularly well-developed by Bemmelen /25/. The literature contains many examples of the application of this hypothesis to an explanation of the specific structures of various folded regions.

A different approach to the connection between folding and vertical movements of the earth's crust is found in the works of Yu. A. Kosygin and V.A. Magnitsky /14, 17/, who derived local compression of the crust from purely geometric reasoning: contraction of the surface during its passage through a chord in the process of vertical oscillations.

On the whole, the original recent contribution of Soviet workers to this problem consists in the differentiation and isolation, from among the folded deformations, of several different types of unlike origin. The first and biggest step forward in this direction was taken by M.M. Tetyaev /22/. From folded deformations, he isolated a large group of "domes" directly associated, genetically, with vertical movements of the earth's crust. Since that time, the idea of different kinds of folded deformations has become widespread among Soviet tectonists. In keeping with this idea, Belousov isolated idiomorphic (intermittent) and holomorphic (complete) folding /2, 3/ which are formed by vertical movements of the crust and by its horizontal compression, respectively. A considerably larger number of genetic types of folding were found by Ye. V. Khayn /23/. V.V. Bronguleev /9/, A.A. Sorksy and I.V. Kirillova /21/, I.A. Rezanov /19/, and others have pointed to a number of types of folding of different origin.

At the same time, Soviet investigators have also pointed to a new mechanism of possible connection between the folding of horizontal crumpling and wave-like oscillatory movements of the earth's crust. Henceforth, this mechanism will be called "dynamic squeezing". This is an outward squeezing of plastic layers from the crest of a growing tectonic uplift, due to the resistance to this growth by overlying strata.

It is thought that in this situation the plastic layers that occur on the crest of the uplift (forming at a certain depth below the surface of the earth) flatten out and are pressed sideways, thus crumpling into folds.

This idea was first expressed in a general form by M.M. Tetyaev /22/ and more concretely, as applied to individual real cases, by V.V. Belousov /3,5/ M.V. Gzovsky and A.V. Goryachev /7/ and V.V. Bronguleev /8/. This mechanism, as a particular one along with others, is recognized by Khayn /23/. It may be noted that salt domes have been regarded by Soviet workers as a special type of tectonic deformation associated chiefly with a light, viscous material coming to the surface inside a heavy material /12, 13/.

Another distinguishing feature of Soviet work on the problem of folding is the great attention paid to problems of the internal mechanism of the deformation of layers during folding. This internal mechanism has been brought to light by studying the details of the "anatomy" of folds. In this connection, mention may be made of the work of Belousov /4,5/, Azhgirei /1/, Sorsky /20/, Kirillova /11/, and others. The investigations were in part accompanied by laboratory modelling /5,16 and others/. Many peculiarities in the behaviour of rocks in the process of folding have been explained, as a result of this type of research.

On the basis of an analysis of all previously collected data the author has long since come to the conclusion that folding in all its manifestations, including the holomorphic (complete) type, should be regarded as a phenomenon derived from the vertical oscillatory movements of the earth's crust. Following Ampferer, Haarmann, Bemmelen, Tetyaev and others, the author of this paper has also done what he could to destroy the concept that folding in geosynclines is caused by horizontal pressure from without. Since this point of view has been argued many times, there is no need to return to the proofs here.

The most difficult part of this theory, which presupposes folding movements to be subsidiary to oscillatory movements, is the question of what process leads to the transformation of vertical movements of the earth's crust into folding movements.

This difficulty arises chiefly in analysing the formation of complete folding - which is directly connected with horizontal compression in the earth's crust.

As has been pointed out, the transformations of vertical movements of the earth's crust into horizontal transposition of its material is usually associated with two processes: the gravitational movement of masses of the earth's crust along the slopes of tectonic uplifts; and the outward squeezing of the material of layers from the crest of uplifts when these layers become flattened vertically during the formation of the uplift. Both of these mechanisms -- gravitational and dynamic squeezing from crests -- lead to one and the same result: the movement of material from the crest of an uplift to the slopes or to adjacent depressions. In this process, the amount of material on the crest diminishes; the total thickness of the masses that develop there decreases, while it increases on the slopes and in depressions. Due to peculiarities in the mechanical properties of stratified masses, any increase in the overall thickness is accomplished by means of crumpling the layers into folds. Thus, the folds form in areas where there is an accumulation of moved stratified material.

When interpreting the structure of folded regions from the standpoints of these two mechanisms -- gravitational and dynamic squeezing -- it is obviously necessary to look for zones of the efflux of material, (from which zones the material was moved by these processes), and zones of injection or accumulation of material, where it has piled up and folds have formed. Traces of horizontal stretching of stratified masses (seen as a general decrease in thickness), lensing out, appropriate fault movements, etc. should be the most probable signs of zones of efflux. It seems most probable that zones of efflux should be located in the axial parts of folded systems, primarily in the axial parts of central uplifts, where the development of complete folding is most intensive. It is thought that one such zone of efflux "services" the entire given folded system, and for this reason should have a considerable width.

A correlation of these conjectures with the actual structure of different folded zones has shown that these conditions un-

doubtedly occur in one concrete case -- a section in the Eastern Alps. Its profile has been published (7) with accompanying explanations.

However, in many other cases, attempts to interpret from this standpoint, the processes of formation of folded regions have met with great difficulties, since there have been no signs of sufficiently broad efflux zones of material in the axial parts of these regions. Such, for example, was the difficulty that arose in the Southeastern Caucasus, inasmuch as in its axial part (from the site where the material should flow), published geological profiles show a steep fan of highly compressed, tall, isoclinal folds; this, of course, contradicted the entire theory.

Two situations were possible: either the theory was wrong or our concepts concerning the structure of the internal parts of folded zones were incomplete. The second possibility did not seem less probable than the first, since it was known that in the process of a general geological survey a study of the structure of complexly displaced zones is of necessity too schematic. It was necessary first of all, to try to determine just how probable this second possibility was. With this aim in view, detailed structural investigations that might yield more accurate data concerning the morphology of folded systems were undertaken. These investigations included the drawing of maps, and, chiefly, the drawing of detailed and precise profiles through whole folded regions.

Special care was taken to see that the profiles were in a single scale and that they recorded both large and small structural forms. (When compiling small-scale schematic profiles, the proper interrelationships between large and small structural forms are distorted.)

To date, observations have been made in the Southeast Caucasus (A.A. Sorksy, A.V. Dolitsky, M.M. Shurygin), in Fergana (40.30°N, 71.50°E) (D.A. Kazimirov), in the Kara-Tau Range (43°N, 70°E) (V.V. Ez, M.V. Gzovsky) in Tadzhikistan (39.0°N, 71.0°E) (M.V. Gzovsky, V.N. Krestnikov), and in the Kerch-Taman 45.19°N; 36.29°E region (N.A. Syagaev, N.B. Lebedeva, O.M. Filatov, V.I. Bashi-

lov).

These investigations are as yet far from complete. However, the results obtained are clearly in favor of our second suggestion. At any rate, detailed investigations in the Southeastern Caucasus have led to results that differ markedly from previous ideas concerning the structure of the internal parts of this folded zone.

In 1955, the author made a trip through the French Alps. This region has been studied in detail and is well exposed; thus it affords exceptional opportunities to observe a number of fundamentally important peculiarities in the structure both of individual folds of different types, and of whole folded systems /6/. The conclusions that follow have been made on the basis of a correlation of the materials of the author and of the investigators just mentioned, and also with the utilization of data from the literature.

It is not possible to say just how universally applicable our conclusions are. To confirm or reject their general significance it is necessary to extend analogous observations to a large number of other folded regions. This will only be possible after the problems touched on below have attracted the attention of many geologists working in different folded regions.

Despite this, however, one cannot escape the fact that observations conducted in regions of such different position and geological structure as the French Alps, Kara-Tau, the Caucasus and Fergana, have led to exceedingly concordant results. This cannot be fortuitous.

Apparently very essential in the process of folding is the fact that in the course of vertical (oscillatory) movements, the earth's crust in many cases splits up into sharply divided sections that reveal relative vertical displacements. Such sections we shall henceforth call blocks. These blocks are separated from each other either by faults or flexures. Apparently, the same scar between blocks at different depths and in different rocks can be in the form of a fault or a flexure. These scars are probably what Peyve called "deep faults" /18/, while the separate blocks that possess independence of movement form

the "elementary zones" which were isolated in geosynclines by Gzovsky /10/.

From the foregoing it does not follow that vertical differential movements of the earth's crust do not also occur by means of gradual bending. It is the author's opinion that such "gradual" or "plastic" oscillatory movements not only exist but are even more widespread than block movements. It should be added that block movements are subject in their development, to the same laws that have been generally established for oscillatory movements of the earth's crust. The point is that in some cases the oscillatory movements develop with continuous transitions from areas of subsidence to areas of uplift, while in others the transitions between them are interrupted. However, in the transformation of vertical movements into horizontal movements in the building of folds associated with tangential compression, it is precisely block movements that play a very important part. This importance of block movements is due to sudden changes in mechanical conditions on the boundaries between blocks. This circumstance facilitates a more energetic transportation of material from uplifts to depressions.

Cases of the division of the earth's crust into "keys" displaced above or below a mean level are common and well-known. Examples include: the southern part of the Fergana depression with its massive box uplifts, the Middle-Cenozoic in Central Europe, the Rocky Mountains, the China platform, and many other regions.

Much less common is the stepped structure of large mountain uplifts. This structure has long since been detected in the Tien Shan Range ( $49^{\circ}\text{N}$ ;  $80^{\circ}\text{E}$ ) with its flight of steps ("counters"). In the most recent literature, a stepped structure has been indicated for the Jura mountains /28/. A visit to the French Alps suggested that the structure of their high-mountain part may be interpreted as stepped /6/. Quite unexpected was the stepped structure detected in the eastern part of the Big Caucasus (Fig. 1 and 2). Figure 1 shows a cut of the slope (the flysh zone) compiled by A.V. Dolitzky. Figure 2 contains profiles compiled by A. M. Shurygin through the central part of the Southeastern Caucasus. The profiles exhibit structural ledges, each of which is composed at the surface, of rocks of a definite and small stratigraphic interval. The surfaces of the ledges are complicated by folding, but the

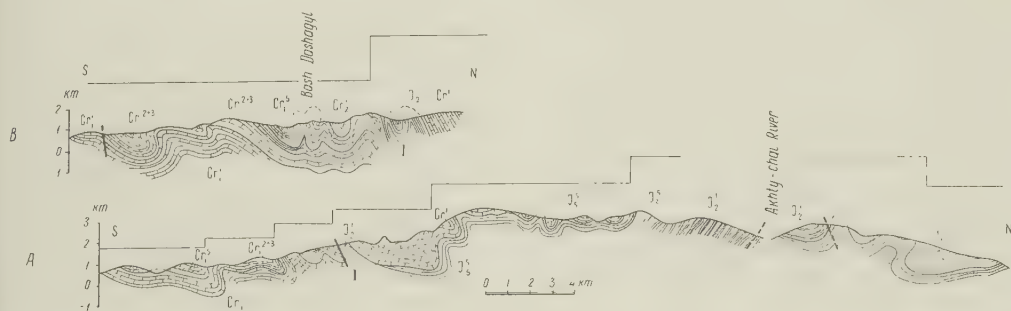


Figure 1. Geologic profiles through the southern slope of the southeastern part of the Main Caucasus Ridge (the region of Nukha). After A. Dolitzky. The broken lines above the profiles demonstrate the position of blocks of the crust. A - principal profile; B - detailed profile of a part of A to the south of the field 1. One can see the crumpling of the layers immediately below the fault.

In their movements, blocks either combine to form what may be called a "key-board of blocks" (the division of a region into relatively elevating and subsiding blocks that have a single mean level), or exhibit an arrangement of successive steps (either going up or going down) that combines to form large stepped uplifts or depressions.

folds within the limits of each ledge are on the same level. However, the age of various series emerging at the surface differs radically from ledge to ledge.

The general inference is that crumpling of layers into folds should be regarded as the reaction of stratified masses of the earth's crust to differential vertical move-

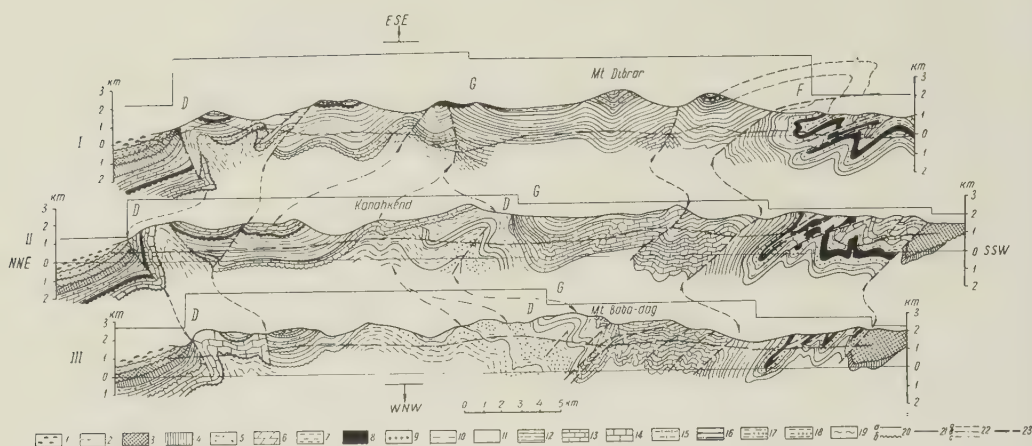


FIGURE 2. Combined geologic profiles through the southeastern part of the Main Caucasus Ridge (between the Mts. Dibrar and Baba-dag). After A. Shourygin. From I to III the profiles are disposed from east to west. The broken lines above demonstrate the positions of blocks of the crust. 1. Upper Miocene; 2. Middle Miocene; 3. Oligocene and Lower Miocene; 4. Paleocene and Eocene; 5. Danian; 6. Upper Campanian and Maastrichtian; 7. Santonian and Lower Campanian; 8. Upper Turonian and Coniacian; 9. Cenomanian and Lower Turonian; 10. Albian; 11. Upper Aptian; 12. Hauterivian-Lower Aptian; 13. Valanginian; 14. Lusitanian-Turonian; 15. Kimmeridgian-Turonian; 16. Callovian-Lusitanian; 17. Middle Jurassic; points - sandstones of the Bayocian; 18. Lower Aalial; points - sandstones; 19. Submarine slides; 20. Stratigraphic contacts: a - conformable, b - disconformable; 21. Tectonic faults; 22. Lines indicating the continuation of structures: a - of faults, b - of anticline axis; 23. Lower limit of the direct observations; D. injection folds, mentioned in the paper; F. southern overturned flexure; G. structural terrace, observed on the west and not visible on the east.

ments of its blocks. In different cases, this reaction is in the form of deformations of extremely varying complexity; but it is always regular, which enables one to arrange individual cases into something like a series, for instance, from simple to more complex deformations. This may be utilized in the following suggested classification of folding which is based, obviously, on a kinematic principle.

Using this principle, I find it possible to distinguish between three types of folding: block folding, injection folding, and folding by general crumpling.

Block folding reflects most directly the differential movements of blocks in the earth's crust. Observations show the blocks to be both bilateral and unilateral. (Fig. 3). In the first case, the folded bend

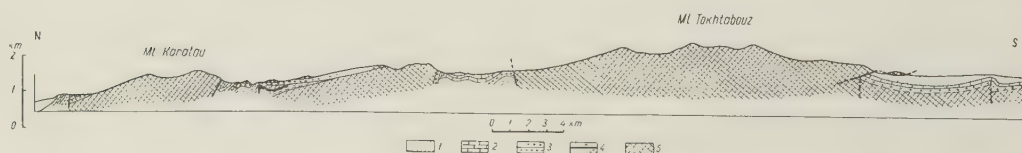


FIGURE 3. Geologic profile through the Mts. Kara-tau, Kourgantash and Tokhtabou (the southwestern Ferghana). After D. A. Kazimirov. 1. Neogene-Lower Quaternary; 2. Paleogene; 3. Cretaceous; 4. Jurassic; 5. Paleozoic.

in the layers overlying the block takes on the form of a box-fold (the Kara-Tau Range); in the second case, the form of a flexure (the Kugantash Range).

Examples of typical block folds may also be seen in Figure 4. Folds of this

of vertical local uplifts of strata, in the same category. We may infer that in many cases such gently inclined anticlinal forms of rocks reflect the more contrasted block movements in the deeper zones in a greatly smoothed form at the surface.

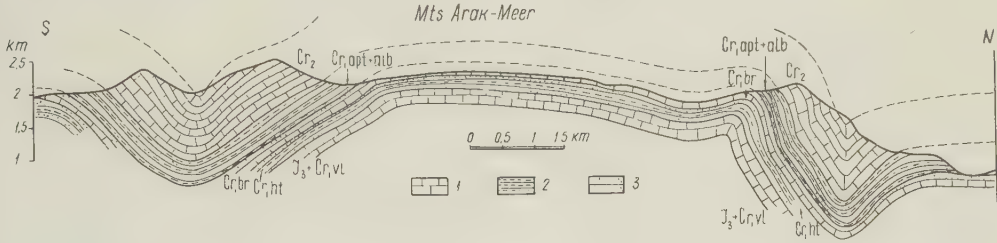


FIGURE 4. Geologic profile through the Limestone Daghestan between the Avar and the Andy Koisou Rivers. After A. Sorsky. 1. limestone; 2. clay; 3. sandstone.

type are extensively developed on the outskirts of folded zones and in regions of parageosynclines. They are found on the periphery of the folded zone of the Main Caucasian Range [in Daghestan, ( $43^{\circ}\text{N}$ ,  $47^{\circ}\text{E}$ ) and in the Kurin ( $40^{\circ}\text{N}$ ,  $48^{\circ}\text{E}$ ) and Rion ( $42.3^{\circ}\text{N}$ ,  $42^{\circ}\text{E}$ ) depressions] in the Western Alps (external zones), in the Fergana depression, in the Rocky mountains, in the Somkhet zone ( $41.15^{\circ}\text{N}$ ,  $44.30^{\circ}\text{E}$ ) of the Minor Caucasus, and in other regions.

Generally speaking, as one moves up the profile such folds become more gradually inclined; both box uplifts and steep flexures develop into more and more gently dipping, swell-like uplifts. Such alterations in the shape of folds are well stratified in simple experiments (Fig. 5).

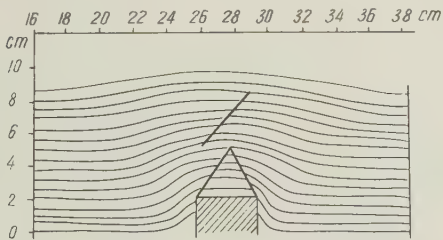


FIGURE 5. Supratenuous character of a box-fold on a model (gun grease); after A. M. Sycheva-Mikhailova.

These changes in the forms of folds upwards along the profile make it possible to distinguish varied swells, brachy-folds, and domes, which are widely developed especially on platforms and are the result

Though I thus include mainly in the block type of folding a broad group of idiomorphic (intermittent) folds (with the exception of diapir domes discussed below), I realize that the terminology should separate gentle swells, brachy-anticlines and domes from the more typical block folds with clear-cut boundaries. Using a term that has rather often been applied before, one may speak of "reflected block folds" in application to a diverse class of idiomorphic folds (with the exception of diapir folds). Yet one must bear in mind that at a depth the "reflected" block folds can pass into more typical block uplifts. However, such a transition need not necessarily be placed at the boundary between the crystalline basement and the sedimentary series; it may either be above or below this boundary. The structure of reflected block folds may be seen on our overall profile of a folded zone (see Fig 13).

The kinematics of folding is naturally reflected in the morphology of the folds; and in large measure it is precisely the morphological characteristics that enable one to refer a given fold to a definite kinematic type. However, in doing so, one must not lose sight of a possible convergence of characteristics. Thus, one of the morphological characteristics of block folds is the box form. Yet not all box folds are of the block type in regard to the mechanism of their formation. Further on we shall regard the folds of the Jura mountains as an example of typical injection folding; yet these folds in the massive

limestones of the Jurassic period that cover plastic injection cores are frequently box-shaped. It is frequently noticed that in a crest-like folded structure, which on the whole I place in the category of injection folding (see below), individual anticlines in the cross-section profile also exhibit a box form. Examples are certain sections of the Terek and Sunzha anticlines in northern Daghestan ( $46.5^{\circ}\text{N}$ ,  $66.4^{\circ}\text{E}$ ).

Consequently, in order to determine to which kinematic type a given fold belongs it is necessary to apply a set of morphologic characteristics, data concerning the structure of the folds at the greatest possible depth, and also information on the history of its development.

Let us again consider a number of kinematic varieties of folds. Complications in the structure of these folds, as compared to the block folds just considered, consist in the appearance and persistent strengthening of horizontal movement of the masses in the background of these very same block movements.

These complications begin with cases of horizontal movement of masses that do not involve all strata, but concentrate in a certain series of exceedingly great plasticity. Within the limits of this series the material flows from some areas and concentrates in others, thus reducing initial thicknesses of the series in some places and increasing them in others. In the latter are formed "injection cores" and "piercement cores." Following this redistribution of material from the underlying plastic series, the overlying strata upwarp over the "injection core" and downwarp over the site from which the material flowed. This is injection folding.

In an attempt to consider the mechanical aspect of a connection between injection folds and block movements, we may note that on the southern slopes of the southeastern Caucasus, according to information supplied by A. V. Dolitsky, there is observed right over the edge of one of the structural ledges an intensive injection in the plastic mass of the lower Jurassic period which pierces the overlying series (see Fig. 1, A1). On profiles of the same region compiled by A. M. Shurygin, one can also see instances of the injection of

material into the forward parts of the blocks facing lower ledges (See Fig. 2, D).

According to V. V. Ez, a similar connection can be observed between the tectonic ledges in the foundation and folds in the overlying plastic mass in the Kara-Taz Range. (Fig. 6.)

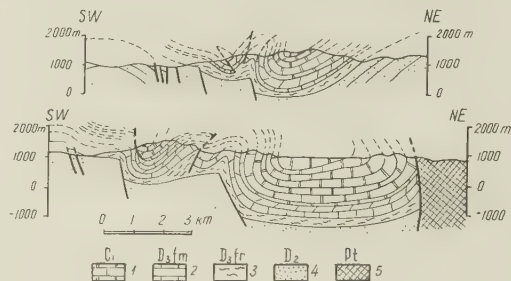


FIGURE 6. Geologic profiles of the central part of the Karatau Ridge. After V. V. Ez.

1. Lower Carboniferous (limestone and dolomites);
2. Upper Devonian (Famennian-limestone and marl);
3. Upper Devonian (Fransian-marl and argillite);
4. Middle Devonian (red sandstone);
5. Proterozoic metamorphic slates.

Figure 7 is a general profile through the Jura mountains. This region is likewise characterized by stepped structure. Transport of material from the plastic masses of the Triassic period is also observable within the limits of each ledge, in such a manner that in the forward part of the ledge facing down the common slope an injection core is formed which is often complex /6, 28/.

It may be said that an injection zone is formed in each block near the seam, separating it from a lower-lying block, whereas the remaining part of the block forms a zone of efflux of material.

Both in the Caucasus and in the Jura mountains injection folds are in the shape of crest-like folding. It is quite obvious that the crest-like folds of Provence (Fig. 8) also belong to the injection fold type. Here, piercement cores in some cases develop into small superficial charriages (for details see /6/).

In the Caucasus, crest-like folds, which probably should be put in the category of injection folds, occupy a peripheral position together with block folds. They

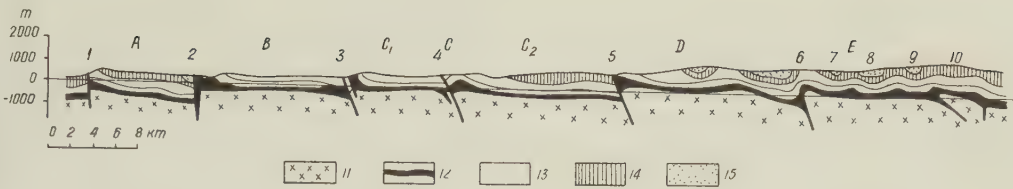


FIGURE 7. General geologic profile through the northern Jura (after Glangeaud). A. Block to the north from Ognon; B. Block of Besancon; C. Block Ornan, divided into C<sub>1</sub> and C<sub>2</sub> by the fault of Mamirolle; D. Block Levier; E. Helvetic folds. 1. Faulty Zone of Saone; 2. Fault of Ognon; 3. Faults of Doubs; 4. Fault of Mamirolle; 5. Folds of Saline; 6. Laveron; 7. Synclinal Planée; 8. Synclinal Saint Point; 9. Synclinal Metablef; 10. Anticlinal Mont-d'Or; 11. Crystalline basement; 12. Triassic; 13. Lyassic and Middle Jurassic; 14. Upper Jurassic; 15. Cretaceous and Tertiary.

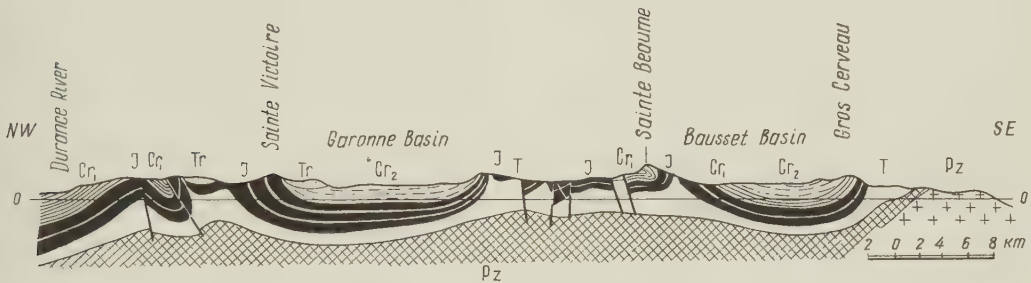


FIGURE 8. Schematic geologic profile through western Provence (after Corroy and Denizot).

are found in the foredeep in Northern Daghestan, in the northwestern and south-eastern subsidences of the Main Caucasian Range, and in the Kura and Rion inter-mountain depressions. By gradual transitions they are intimately connected with the clayey diapirs of the Apsheron and Kerch-Taman region.

The injection folds in the Western Alps are likewise regularly associated with the same external zone that has well-developed typical block folds. Injection folding is apparently a regular concomitant of block folding where the thickness of the sedimentary unmetamorphosed rocks is relatively great and where, among them, there are considerable masses of highly plastic rocks.

In all the foregoing cases, the block structure apparently favors the formation, in a folded region and during the build-up of injection folds, not of a single, large, general zone of efflux, as formerly thought, but of many individual efflux zones associated with each block. Each such individual zone "serves" its own injection zone located

within the limits of the given block. And in each case the distance the material is conveyed is small.

Glangeaud (28) considers the cause of formation of injection folds in the Jura mountains to be the uneven gravitational pressure of overlying masses on the plastic series of the Triassic period (in accordance with the diagram given in Fig. 9).

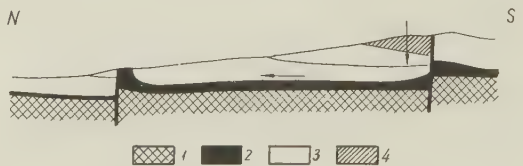


FIGURE 9. Mechanism of the formation of the structure of the Jura Mountains (after Glangeaud). 1. folded basement; 2. plastic triassic; 3. Jurassic; 4. Cretaceous.

I believe that in the formation of injection folds, this mechanism of squeezing out of a plastic series by the unevenly distributed weight of overlying masses plays a leading role. There appears to be two stages in the development of folds of

this type: during the first stage, over the edge of a unilaterally rising block a swelling uplift is gradually formed that is eroded from the surface. Simultaneously, adjacent depressions slowly subside and sediments accumulate. When the difference of pressures on the plastic series in the depressions and on the uplift becomes great enough and when the cover of the plastic series in the anticlines is close enough to the surface and the resistance of the overlying masses diminishes, the material of the plastic series is injected into the core of the anticline and is even squeezed out onto the surface due to the weight of rocks accumulated in adjacent depressions. Separate stages of this process are shown in our general diagram of the structure of a folded zone (see Fig. 13, P, S, T). Cases of crest-shaped injection folds forming over the scar of a unilateral block appear to be most prevalent, though, of course, they are not the only cases. The base of an injection fold may also have bilaterally raised blocks or gradually dipping swell-like uplifts.

It is quite natural that the process of squeezing will be aided by reverse relief (highlands over structural depressions and hollows over anticlines), and also by the reduced specific weight of rocks of the plastic series as compared to the overburden. Both these factors are in operation in the Jura Mountains with their reverse relief, where the rocks of the salt-bearing and gypsiferous formations of the Triassic are obviously lighter than the Jurassic limestones that cover them. In the Provence only one factor (specific weight) is in operation, whereas in the Kerch peninsula, for example, two factors again appear. Characteristic of this region is a reverse relief; the Maikop clays that are subjected to injection have a reduced specific weight because they are saturated with water that is full of mud volcano gases.

In these cases, the relief and difference of densities combine to act with the block movements of the basement. However, extreme cases are entirely possible when these factors -- relief and different density -- act independently of block movements (and of one another). If the plastic mass is opened at the bottom of an erosion depression it may be subject to squeezing

without any block movements at a depth and without reduced density. In another case, when there is only a difference in density, that is, when a highly plastic series of light rocks occurs under heavy rocks, the entire process consists in a slow rising of the lighter material inside the heavy material /16, 39/. An example of this is the diapir salt dome.

Such folds and domes of gravitational "surfacing" are being formed even at present, and at times under very peculiar conditions. Thus, for example, in Japan, there are injection folds formed as a result of the squeezing of plastic clays due to the uneven weight of coarse pyroclastic debris falling on them /37/. Plastic clays form typical diapir cores under the uneven weight of coarse alluvial deposits in the Mississippi delta /42/, etc. According to V. V. Ez, in certain regions of the Karatau Range cases are observed where the relief plays a leading part in the building up of uneven pressure from above and in the transport of material culminating in the formation of folds, which are broadly characterized by injection folding.

Thus, the conditions of formation of injection folds appear to be rather complex. Yet it is necessary to make them still more involved. Figure 10 depicts a

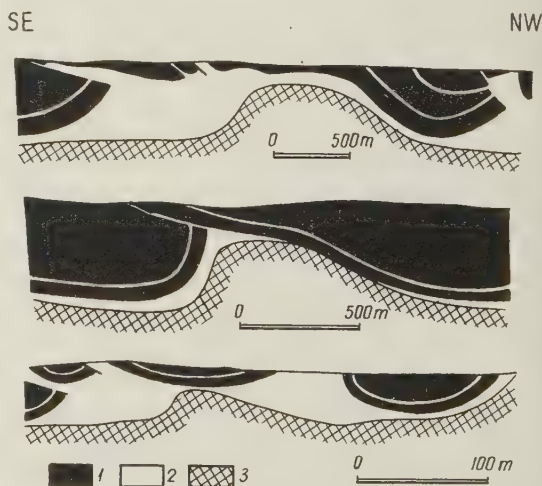


FIGURE 10. Geologic profiles through the salt-bearing region of southern Iran (after O'Brien). 1. Upper hard series (Middle Miocene-Oligocene); 2. Plastic series (Lower and Middle Miocene); 3. Lower hard series (Lower Cambrian-Lower Miocene).

profile through a region of the development of salt diapirs in Iran /38/. It is obvious from this profile that in this case the injection phenomena are associated not so much with gravitational "surfacing" as with dynamic sideward squeezing of a plastic mass from the crests of dome-like uplifts (reflected block folds) during the growth of these uplifts, and under conditions where the overburden offers resistance. The injection sites of plastic rocks and their squeezing to the surface are probably predetermined by earlier existing faults in the overlying rocks.

There is thus observed yet another mechanism of the formation of injection folds: dynamic squeezing of plastic rocks from the crests of block uplifts with injection of these rocks along faults in the overburden.

Taking into account what has been said, we may state that the following factors may contribute to the formation of injection folds:

(a) gravitational squeezing due to non-uniform load; note that the non-uniformity of the latter may be connected with the relief and the structure (squeezing from under sections with a relatively raised relief and from under tectonic depressions where the thickness of the overburden is greater than on anticlines);

(b) gravitational "surfacing" due to the difference in specific weights when a light-weight plastic series underlies a heavier series;

(c) dynamic squeezing from the crests, under conditions of the crushing of strata from a developing block (or reflected block) uplift.

These processes may operate jointly, in different combinations. However, attempts to separate them and establish a role for each one cause great difficulties in specific cases. These difficulties are associated, first, with a lack of data (only in rare cases do we reliably know the structure of deep-lying parts of injection folds), and, secondly, with the fact that all the enumerated processes act conformably in a single direction, and in general, lead to the same structural results. We

shall see that similar difficulties arise when we consider the formative conditions of folds of general crumpling.

This complex origin for injection folds cannot, however, prevent us from regarding them as a definite integral group of folded deformations that occupy a very prominent place among folded structures as such, and belong to definite geological conditions.

Injection folds are characterized by: (1) the presence of thick, sedimentary masses which include series of highly plastic rocks; (2) a relatively even general tectonic background of a gently differentiated system of vertical movements of the earth's crust. It is precisely the slight intensity of the differential vertical movements that determines the small degree of the forces -- connected with gravitation or the squeezing from crests -- that bring about this folding. These forces are sufficient to produce horizontal flow of the more plastic masses, but are not sufficient to be the cause of general crumpling of all the rocks. A situation like this is observed in frontal and intermountain depressions and in deep-lying synclines (basins).

The third type distinguished is folds by general crumpling. By these are understood folds of longitudinal extent which are, as a rule, developed in considerable groups, and are simultaneously manifest in masses of rocks of great thickness and diverse composition. Morphologically, this is complete (holomorphic) folding.

Formation of this type of fold requires the action of horizontal compression in a very thick heterogeneous mass.

The contraction hypothesis and a number of other hypotheses explain this compression by various general causes of contraction on the surface of the earth. Haarmann's hypothesis of gravitational folding assumed a general transport of masses within the limits of a large folded system and required a broad zone of efflux of material in the axial part of the folded region. As was pointed out at the beginning of this paper, both of these explanations were rejected as contradictory to observations. Attempts were then made to find

more intimate, direct, and particular causes of horizontal compression of individual sections of the earth's crust. The aim was to find such causes and then determine how adequate they were to explain observed folding.

Observations show that horizontal compression arises, for example, in surrounding rocks near relatively elevated blocks of the earth's crust. When some block rises above adjacent blocks, there is very often observed a tendency to expand or, more precisely, for the upper part of this elevated block to spread outwards. When this block is bounded by visible faults, the faults (in connection with this spreading) have a tendency to dip fan-like near the earth's surface and to pass from vertical faults into thrust faults; at first steep and then more gently dipping, as far as the horizontal.

This phenomenon is very readily seen, for example, on the accompanying profiles through the southeastern Caucasus compiled by A.M. Shurygin and especially on one of them (see Fig. 2, I, F). On this profile the entire cross section through the axial part of the southeastern Caucasus gives us a picture of a single elevated block that overthrusts fanwise both to the south and to the north.

The expanding block presses on the surrounding rocks horizontally, thus causing crumpling of strata into folds in adjacent sections. This phenomenon is very easily seen on Shurygin's profiles, especially under the southern boundary of the elevated block in the axial part of the southeastern Caucasus (see Fig. 2, III, G), and also in Fig. 1.B.

D. A. Kazimirov is of the opinion that folds observed between elevated blocks in Fergana (see Fig. 3) can be explained in the same way. It is thought that these blocks (in the shape of box uplifts with Paleozoic rocks in the core) spread out at the top and crumpled the layers of the Mesozoic and Tertiary rocks between them into folds.

If the blocks are arranged in steps, one above the other, as is the case in the internal parts of a folded zone, there occurs a unilateral thrust of each higher

block over the one below. According to A.V. Dolitsky, this is the picture observed on the southern slope of the southeastern Caucasus. Here, step-wise arranged blocks move onto one another, progressively crumpling one another into folds near the surface (see Fig. 1).

An extreme case of such action of stepped blocks on each other is observed in the French Alps. It has been stated /6/ that since the tectonic zones distinguished in the Western Alps are differentiated by the history of oscillatory movements, the faults that separate them ought to have been originally vertical. They probably did remain so deep down, but in their upper part near the surface they acquired an inclination of  $45^{\circ}$  to  $50^{\circ}$ . Thus the upper parts of the blocks here are upturned, one on the other, as in the Caucasus. But in the Alps this overturning is especially intense, probably because the blocks in this mountainous country form a steeper step system. The result is that the upper parts of the higher blocks lie on the upper parts of the lower blocks and crush them. The strata of the crushed blocks are crumpled into closely compressed isoclinal folds that are flattened and lensed out. The great intensity and specific nature of the dislocations in the internal zones of the French Alps are also determined by the special mechanical role of plastic rocks of the Triassic and, to a certain degree, of a Paleogenic flysch (Fig. 11). Strata in the uppermost blocks that occupy the axial part of the ridge and that are not subject to pressure from above, occur and for a broad, gently dipping syncline.

Conditions change but little in cases when the blocks are bound not by faults but by plastic bends of the strata -- flexures. The expansion of the upper part of the block then leads to a transformation of the vertical flexure into an overturned boundary fold (see, for example, Fig. 2 D and F, and also Fig. 1). As for the tangential pressure on the rocks of the underlying block, all remains as in the preceding case.

There can hardly be any doubt that the principal reason for the elevated blocks spreading outwards is the force of gravity. What we have is the result of the outward

plastic flow of elevated parts of blocks due to the weight of the constituent rocks. However, we may confidently say that, as with injection folds, folds produced by general crumpling are connected not only with the gravitational mechanism, but with the mechanism of dynamic squeezing as well. Above, we referred to the structure of Tirol as exemplifying the action of this mechanism. It is reasonable to expect that dynamic squeezing should be observed mainly at a certain depth in the earth's crust, whereas the gravitational mechanism predominates near the surface.

In this case the horizontal movement of material that occurred due to a thick layer of overburden is probably connected with the mechanism of dynamic squeezing (Fig. 12).

From the results of the investigations of the A.A. Sorsky /20/ it may be inferred that the small folding with vertical joints in the Archean metamorphic masses of the White Sea region is due to horizontal pressure on the strata of these masses of granite that have been intruded in the shape of huge domes. Here too, the horizontal

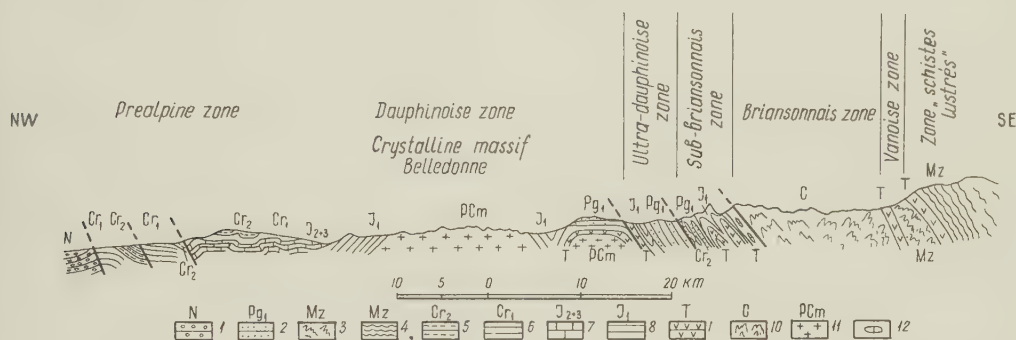


FIGURE 11. Schematic profile through the Alps of Maurienne (along the river Aran). 1. Neogene; 2. Paleogene (mostly flysch); 3. Strongly deformed Mesozoic; 4. Schistes lustrés; 5. Upper Cretaceous; 6. Lower Cretaceous; 7. Middle and Upper Jurassic; 8. Lower Jurassic; 9. Gypsum bearing Triassic; 10. Carboniferous and Permian; 11. Crystalline rocks; 12. Blocks of Mesozoic tectonically inserted in other rocks.

Of great interest in this respect is the structure of the "Central Metamorphic Complex" of northeastern Greenland described by Haller. The author shows that the migmatite material of the metamorphic foundation rose in the form of domes (our "blocks", but in a very plastic state) and at the top, spread out horizontally in the shape of covers and mushrooms /31/.



FIGURE 12. Scheme of the structure of the metamorphic complex of Greenland. (After Haller). 1. migmatite; 2. metamorphic slates; 3. Paleozoic sedimentary rocks.

pressure that occurs at a considerable depth should be attributed to the dynamic squeezing associated with the pressure that the granites encounter during their intrusion from the weight of the overlying rocks.

Our acquaintance with the structure of folded zones shows us that the action of these mechanisms cannot explain the formation of all folds. There are widespread folds whose origin is not easily associated with pressure from adjacent blocks, either because these folds are some distance from the blocks or because they belong to the most elevated ones. At present we are unable to resolve completely the problem of the origin of this group of crumple folds. However, certain arguments may be advanced. So far, when considering the conditions of fold-formation, we have confined ourselves to the mechanical aspect of the problem and have not at all touched on the history of the folded structure. Yet

an historical examination of the development of folds may supply additional possibilities for interpreting the mechanism of their formation.

For example, block elevation may not be uniform; one part may rise first, and then the movement may spread to its other parts. The results may be that at different stages in the movement of the block its boundaries may have different positions; and the formation sites of boundary folds and crumple folds near the elevated block may in time migrate. But insofar as the folds (once formed) remain, they gradually cover a certain surface as the boundaries of the block move.

Profile II (Fig. 2) shows that the first to rise was the northern (left-hand) part of the principal block; then the block as a whole began to rise. This is evident from an elementary analysis of interrelationships between the strata. A comparison of the profiles given in this figure shows immediately that the relatively more western ones exhibit a greater cutting up into blocks than do the eastern ones; moving eastwards one observes a sort of combining of blocks. But though on the very eastern profile there actually remains one broad, elevated block, inside there is observed a fold in precisely the position in which the more western profiles exhibit one of the structural steps between the blocks (see Fig. 2, G). Thus, certain folds can exhibit something of the nature of hidden boundaries between blocks.

Very important for an understanding of conditions of fold-formation of this group are observations carried out by A.A. Sorsky in mountainous Daghestan. He observed folds on the surface of the most elevated blocks in the axial part of the main Caucasian Range. These folds are small in size and rather irregular in arrangement and shape. Sorsky noticed that the strata, crumpled into folds, exhibit signs of layer-by-layer stretching in the form of boudinage and separation of the relatively less plastic layers into individual spaced pieces. Yet the very same folds are split by flow cleavage parallel to the axial surfaces, which are predominately vertical.

Mechanically speaking, these two

peculiarities in the structure of folds are contradictory, for if the first peculiarity suggests horizontal stretching of the beds, the second is indicative of the opposite -- horizontal compression. It would appear that this contradiction may be overcome by assuming that the two phenomena developed at different times: the horizontal layers were first stretched and then compressed, crumpled into folds and cut by vertical flow cleavage. A problem arises here that must yet be studied and solved.

A.V. Dolitsky suggested that folds of longitudinal bending may be obtained as a result of multiple up-and-down oscillations of a section of the earth's crust, if these layers, under such oscillations, are alternately stretched slightly and subjected to horizontal compression. Indeed, it is known that strata stretch during the formation of an uplift produced by vertically directed forces. In the tension process they become less thick and given the proper conditions, they lens out. If there is later observed in the region of the uplift, a slight subsidence, the surface of the moving section again diminishes; the stretched strata are too "broad" for it, and as they sink with the block they crumple into folds. Dolitsky believes that if these movements are repeated many times they are able to produce large folds.

This hypothesis is hardly justified. A much more complete study must be made of the very initial fact -- the structure of folded strata -- before we are able to formulate a concept of the origin of such folds. Yet attention may be drawn to one more phenomenon. In Fergana, the slopes of relatively elevating blocks sometimes exhibit sharp folds extending outwards like two "ears" from the sides of the block (Fig. 13.B.). The opinion was expressed (D.P. Rezvoi and D.A. Kazimirov) that such folds could have formed as a result of movements of the block, first upwards and then downwards: in the upward movement the strata on the boundary flexure stretched, diminished in thickness, and in the subsequent downward movement they became too wide and crumpled into folds.

Thus, apparently, the role of vertical oscillations of blocks of the earth's crust in the formation of at least some folds, is

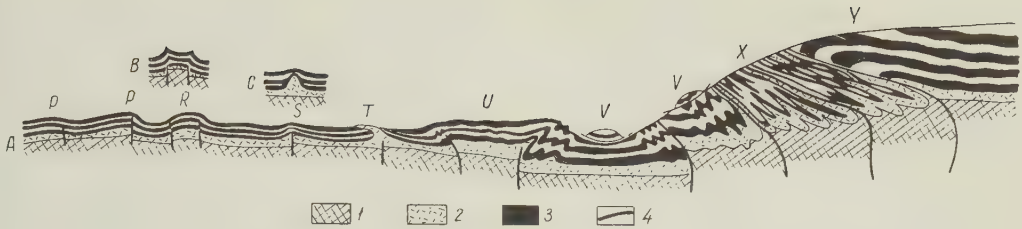


FIGURE 13. Scheme of the structure of a folded zone.

A. Principal scheme.

1. Crystalline basement; 2. Rocks of high plasticity; 3. Different sedimentary rocks; 4. Tectonic faults; B. Box-fold with two minor border folds; C. Diapiric dome; D. Unilateral and R. Bilateral block folds; E. Injection folds; F. Injection fold with piercement core; G. Block fold bordered by overturned flexures; H. Gravitational thrust; I. Zone of crushed rocks; J. Middle block slightly deformed.

is worthy of further consideration.

Likewise, one must not lose sight of the possibility of fold formation in the zone of efflux of material, and stretching of strata simultaneously with stretching as a result of "onflowing" material during uneven efflux. Such "onflowing" has been noted by Sorsky /20/ and I have also had need to touch on this question in one of my papers /5/. It is interesting to note that the phenomenon of "onflowing" has been obtained experimentally too.

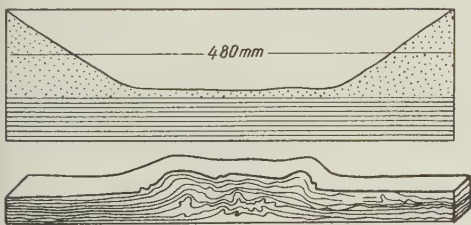


FIGURE 14. Formation of folds in the zone of squeezing out of plastic material on a model (resin). Above -- initial stage; resin under nonuniform load of sand; below -- final stage. Experiment of N. B. Lebedeva.

Figure 14 is a sketch of this structure: it is readily seen that in the zone of efflux where the strata had been subjected to flattening normally to the bedding, "onflow folds" were formed (right-hand part of lower drawing) in the background of a general squeezing of material.

In places where the earth's surface is steeply inclined and where there are plastic masses in suitable conditions of occurrence, the structure is complicated by free gravitational sliding (slipping) of individual packets of rock under the influ-

ence of the force of gravity. This produced the charriages in the French Alps /6/. The strata of sliding packets crumple into folds. However, it appears to me that free gravitational sliding does not play an essential role in the formation of the structure of a folded zone. As observations on the thrust-mass of Embrunais in the French Alps show, folds produced in this way are very small and irregular in shape and in arrangement.

Here, it is again worth mentioning the significance of stepped structure in folded zones in regard to folding. If it were a case of free, gravitational flowing of material down an even, smoothly inclined slope of a central uplift, the result would be the formation of folds mainly at the foot of the slope, since after the down-flow there would be an accumulation of folds at the foot. Besides, depending on the rate of flow and the nature of the material, the fold front would form numerous festoons and bends at the foot of the slopes.

Steps are obstacles to the flow of material and play the part of numerous dams. This is why folds are more evenly distributed over the slopes of uplifts and are not concentrated only at the foot. The block boundaries control the extent of the folds. Thus, their size becomes more stable.

Bemmelen points to yet another concrete, gravitational mechanism of tectonic movement /25/. He suggests the possibility of rotation (around the horizontal axis extending the length of the mountainous uplift) on a lens-like packet of rocks in such a way that in the upper part of the slope there appear normal faults of

tension, while in the lower, thrust faults of compression (Fig. 15). Certain peculi-

"surfacing", sliding and spreading; squeezing from crests; and alternate tension and

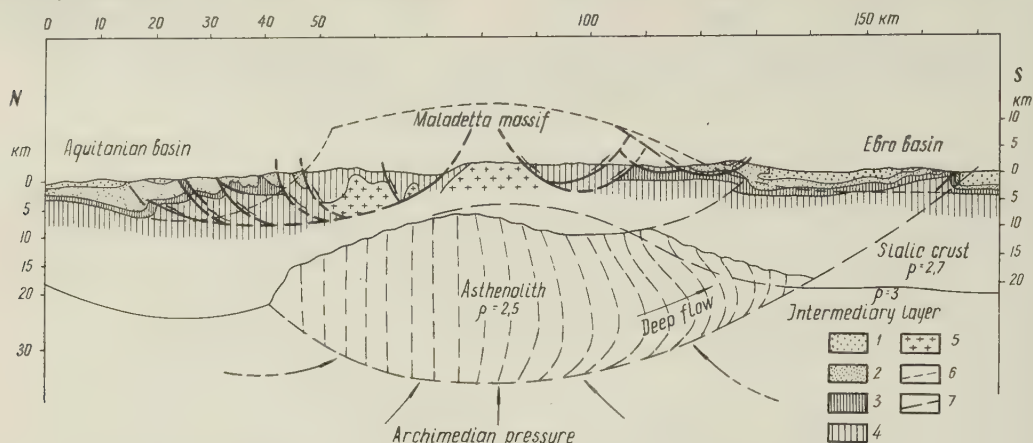


FIGURE 15. Scheme of the gravitational tectogenesis, after Bemmelen (on the example of the Pyrenees). 1. Tertiary; 2. Jurassic-Cretaceous; 3. Permian-Triassic; 4. Paleozoic; 5. Hercynian granites; 6. Surface of basement complex if no erosion and no gravity collapse had occurred; 7. Contact between asthenolith and stalic crust before the deep flow took place.

arities in the structure of the coal basin of Northern France can, apparently, be explained in this way (Fig. 16). Bemmelen

compression of strata due to oscillatory motions. Even if we confine ourselves to the formative conditions of complete fold-

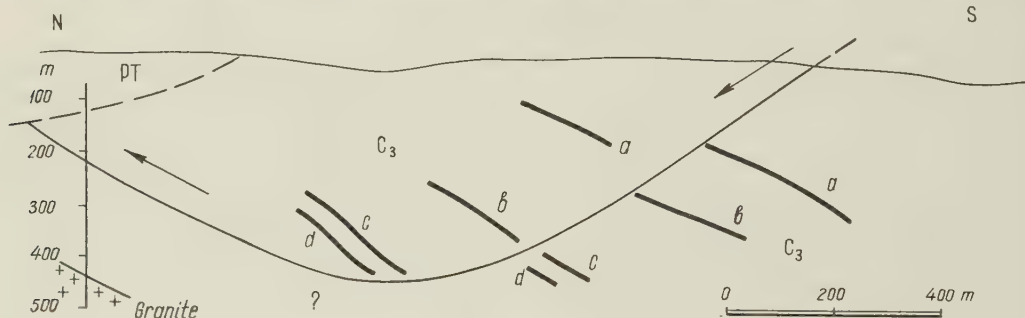


FIGURE 16. Schematic profile through the northern coal-bearing region of France (after Pruvost). One can see the displacement of coal layers, indicated by letters.

likewise considers the possibility of a deep-seated outward flow of material from under the elevated regions in the process of gravitational adjustment (see Fig. 15).

## SUMMARY

Summarizing the arguments concerning the origin of folding, we may say that our picture encompasses a rather extensive diversity of processes that lead to crumpling of strata into different types of folds. These include the direct action of the movements of crustal blocks on stratified masses; gravitational squeezing which manifests itself in different forms; gravitational

ing, a considerable diversity of mechanisms still remains.

It may seem that such a broad range of causes contradicts the universal manifestation of complete folding and its apparent morphological uniformity. It would seem that the broad distribution of generally similar folded dislocations should require rather identical causal processes.

However, certain facts must be taken into account. First of all, on closer acquaintance with complete folding, the idea of a homogeneity in its structure is no longer valid. Indeed, folded zones

exhibit groups of folds that differ radically, both as to morphology and, apparently, as to the mechanism of formation. Further, crumpling into folds is a regular and most ordinary reaction of stratified plastic masses to longitudinal compression. Any other reaction (if, of course, we disregard faults) in a stratified medium is hardly to be expected. Crumpling into folds arises in the case of a sufficiently strong longitudinal compression, irrespective of the causal agent. Thus, even morphologically identical folds can have different origins. However -- and this is exceedingly important -- all these causes are such that they naturally arise jointly and are best developed in regions with intensive and contrasting vertical movements, that is, in geosynclines. Indeed, all the enumerated immediate causes of complete foldings are based on contrasting vertical movements of the earth's crust that lead to inclines on the surface (which are necessary for gravitational sliding), to uneven distribution of loads, to squeezing from crests, and to alternate tension and compression of strata. The formation of complete folds of different origin in the same zone is from this viewpoint understandable.

No less essential is the fact that within the limits of a geosynclinal zone, individual groups of folds in different places can have unlike origins or at least different mechanisms of formation. From this viewpoint, the concrete and immediate causes of crumpling into folds may be of a local character, though their more general basis (in the form of an appropriate development of oscillatory movements) is the same.

Still, it is possible to find a common factor also in the mechanism itself of formation of folds that are due to unlike causes. In all the cases that we have discussed the folds were formed as a result of the redistribution of material which flows out at one spot and accumulates at another. The efflux of material is linked up with a reduction of the thickness of the entire series and of its separate strata, and with a corresponding increase of the surface of the latter. Compression, which balances this tension of strata, develops in places where the material accumulates. But since this compensation occurs not by way of a reverse increase of the thickness of the layers and a reduction of their surface,

but by means of crumpling of layers into folds, we may say that the latter are formed at the expense of an overall increase of the surface area of the strata, which, having stretched, are forced to fit themselves into the original area.

This conclusion is of cardinal importance. Up to the present, the most common views have proceeded from just the opposite principle; they assume a contraction of the surface of a given section of the earth's crust with the surface area of the strata remaining constant. These strata are then forced to crumple into folds in order to fit into this contracted space. In the concept expounded here the situation is just the reverse, and that is what is important. For this reason, efforts should be directed towards possible reasons for the surface of the strata increasing, this increase being the main link in the mechanism of fold-formation. Some of these reasons are given above, but they cannot exhaust all possibilities.

A few supplementary remarks of a general nature still remain to be made.

It should not be thought that when one speaks of the mechanism of squeezing or the gravitational mechanism, the matter is confined to the deformation of the sedimentary, unmetamorphosed cover. In many deformations, the rocks of the crystalline and metamorphic basement can and should participate too. Such participation is indeed absent, for example, in the case of the Jura mountains, where the folded deformations are concentrated only in the sedimentary layer. But when stepwise arranged blocks act on one another, as is the case in the internal zones of the Alps, rocks of the base are also subjected to crushing and deformation together with sedimentary rocks (see Fig. 11). In this connection it should be noted that a radical reconsideration of the prevalent view as to the "rigidity" of the crystalline basement is long overdue. Metamorphic rocks with their schistosity and transformed internal structure, which is characterized by oriented arrangement of the minerals and by development of minerals with a flat and "sliding" surface, undoubtedly possess, in many cases, greater plasticity than many sedimentary rocks under identical conditions. Accordingly, during the for-

both gravitational movements and dynamic squeezing. If, however, complete folding, that is, folding by general crumpling, develops (as follows from observations) by individual phases, this circumstance should be regarded as a reflection of corresponding inconstancy in the relative movements of blocks that form the central uplift. The cause of inconstant growth of a central uplift is not known, but it can be seen that even in the case of schistosity, instability in time is in general peculiar to intensive vertical movements of the earth's crust. Consequently, phases of folding are epochs of a temporary intensification of contrasts in the vertical movements of blocks, increase in the relative heights of the steps, and in the angles of slopes. At this time an intense moving of material develops under the influence of gravity or as a result of dynamic squeezing. Movement ceases when the necessary amount of gravitational adjustment has been achieved and when a state of equilibrium sets in between the force of gravity and the limit of plasticity of the rocks, or when the contrasts and inclines are smoothed over due to temporary reverse movements.

From what has been said there emerges a very definite vista for further investigations on the problem of the origin of folding. We must continue detailed structural investigations in order to encompass different folded regions. This research should be aimed at studying all the structural peculiarities (including even the smallest) of layers crumpled into folds, and at pinpointing the concrete, local causes of fold-building in each case and for each individual section of the folded zone. These causes may, in the same place, be different for folds of different orders and different ages. For instance, folds produced by gravitational sliding can be complicated at the slopes and especially in the crests by squeezing folds due to material that has been flattened at the slopes of gravitational folds and squeezed into crests.

In this work, experiments are important and purposeful. Models of folds of unlike origin can be very helpful in establishing conditions under which the various causes of fold-building operate, and in working out criteria to be used in nature when drawing conclusions about the formation of various folds. The views expounded in

mation of folds of block origin, the crystalline basement does not necessarily react only with fractures: it can also bend plastically to form swell-like and dome-shaped uplifts.

A few words may be added on how epochs and phases of folding fit into the concept under consideration. At present no doubts remain as to the fact that intermittent folding is formed slowly and gradually in the course of long periods of geologic time. In the language of kinematic classification, this should include block folding in all its varieties. This same, long-time formation is also characteristic of injection folding, which is either indirectly connected with movements at the depths of blocks or is dependent on the slow processes of gravitational squeezing or gravitational "surfacing."

But in the background of the long-persisting process of these types of fold-development, there are observed periods of intensified and relaxed growth of folds. This unevenness of formation as exemplified by block folding is apparently due to unevenness of the very process of block movements in the earth's crust. As to injection folding, the process can be more complicated. On the one hand, the unevenness of growth of this type of folds reflects the unevenness of the principal process of movements of deep-lying blocks. However, other phenomena too can play a part.

In modelling the formative process of salt domes, it was found that the growth of the domes ceases when the thickness of the mass covering the diapir core reaches a certain critical magnitude [39]. Thus, epochs of general depression of the earth's crust in the region of salt dome development and the more rapid accumulation of sediments, are less favorable for the growth of domes (and, probably, injection folds in general) than epochs of uplift and erosion. This then explains the long known fact that the growth of diapirs is more rapid during uplifts of the earth's crust than during regressions.

Epochs of complete folding fit the time of origin and growth of central uplifts in geosynclines. With the appearance of central uplifts, conditions are created for

in this paper make definite demands of the experimentation technique and, the properties of the model materials. The latter must on the one hand, enable one to build stratified samples which permit a study of their internal structure following deformation, and, on the other hand, must be deformable under their own weight -- the deformation proceeding at a rate convenient for the experiment.

And now, a concluding remark. Up to the present geologists have studied the structure of a folded region, usually without considering it necessary to examine the causes of complete folding. These causes appeared to be somewhat obvious. This attitude towards folding stemmed from the contraction hypothesis that reduced all folding to a general contraction of the surface of the earth. Naturally, if these views are accepted there is no need to examine the causes of folding in each individual case.

The concept expounded here requires that the geologist do more. His task in any regional investigation that embraces a large enough area is to study the mode of formation of the observed folds, noting that the mode can vary from region to region. The geologist should question the local causes the folding that stem from the local concrete conditions of tectonic development.

This conclusion is by no means comforting. A phenomenon which we had considered simple, associated with only one cause, now appears to be complex, diversified and dependent on different causes. This considerably expands the problems that confront us in this field. However, these problems become much more concrete than before. Very often a more thorough approach proves geologic phenomena which only recently has seemed simple, to be exceedingly complex.

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# STRATIGRAPHIC CLASSIFICATION AND TERMINOLOGY<sup>1)</sup>

prepared by the  
Interdepartmental Stratigraphic Committee, USSR

• translated by John Rodgers<sup>(2)</sup> •

The geological-survey work that has been widely developed in the USSR has required in the first order of business the unification of stratigraphic terminology and nomenclature. To this end in 1952 in the All-Union Scientific-Research Geological Institute (VSEGEI), a special stratigraphic commission was organized, composed of:

L. S. Librovlch (Chairman)  
L. I. Krasny  
A. N. Krightofovich  
N. P. Luppov  
B. P. Markovsky  
A. P. Rotay  
V. D. Fomichev  
N. E. Chernysheva (Scientific secretary)  
S. V. Yakovleva.

In 1953 the composition of the commission was somewhat changed, and it was formed of the following persons:

T. S. Librovlch (Chairman)  
T. N. Alikhova (Scientific secretary)  
L. I. Krasny  
A. N. Krightofovich  
M. V. Kulikov  
N. P. Luppov  
B. P. Markovsky  
S. A. Muzylev  
A. P. Rotay  
V. M. Sergievsky  
P. K. Chikhachev

In 1954 the commission completed its work, and its results were published in a separate book (Stratigraphic and geochronologic subdivisions, edited by L. S. Librovlch, Gosgeoltechizdat, 1954). For purposes of wider discussion of the questions touched upon in this book, the All-Union

Congress on General Questions of Stratigraphic Classification was assembled in January 1955 at VSEGEI, attracting the attention of wide circles of Soviet geologists. The conference accepted a series of substantial additions and corrections to the project proposed by the stratigraphic commission of the VSEGEI, and the wish was expressed to continue this work, completing the working out of the necessary principles of stratigraphic classification and terminology for the territory of the USSR. All materials were transferred to the Interdepartmental Stratigraphic Committee, which for the preparation of a definite text of the work called for was formed into a commission with the following composition:

A. P. Rotay (Chairman)  
N. N. Bobkova (Scientific secretary)  
L. S. Librovlch  
V. V. Menner  
N. K. Ovechkin  
G. P. Radchenko  
V. E. Ruzhentsev  
B. S. Sokolov  
E. V. Shantsev

B. P. Markovsky and A. A. Polkanov and others also took part in the work of the commission.

The project worked out by this commission was further subjected to supplementary discussions, and it is accepted by the Interdepartmental Stratigraphic Committee as a provisional statement, which now is being published under the title "Stratigraphic Classification and Terminology."

## GENERAL PREMISES

Stratigraphy is a branch of historical geology embracing questions of historical (chronologic) sequence, of the correlation and geographical extent of the sedimentary, igneous, and metamorphic rocks composing the Earth's crust and reflecting the

<sup>1</sup>STRATIGRAFICHESKAYA KLASSIFIKATSIYA I TERMINOLOGIYA, State Scientific-Technical Publishing House for Literature on Geology and Mineral Resources, Moscow 1956.

<sup>2</sup>Translated by John Rodgers, Yale University. Translation edited by D. V. Nalivkin.

natural stages in the development of the Earth and of the organic world that populates it. The basic aims of stratigraphy are:

1. The examination of specific chronologic correlations of rocks for various parts of the Earth's crust as the indispensable prerequisite to solving the problems of structural geology, geologic mapping, and exploratory work for useful minerals.

2. The construction of a unified scale of relative geologic chronology for the entire Earth, i. e., a unified system of periodization of the history of the Earth, as the indispensable basis of any historical-geological research.

The immediate objects of stratigraphic research are the successions of stratified sedimentary and volcanic rocks, for in them the chronologic correlations are expressed most simply and clearly, subject to the evident principle: "In normally deposited sediments, the overlying layer is always the one laid down later." The place of other kinds of rocks in the general chronologic scheme is then determined by their relation to these layered successions as to a standard. Thus intrusive rocks, for instance, in a large majority of cases are not directly studied by stratigraphy, but appear only as one of its indirect objects.

Out of the definitions formulated above follows a conception of stratigraphic and geochronologic classification and the requirements to which stratigraphic and geochronologic subdivisions ought to correspond.

It is impossible to agree with the initial premisses in the article by H. D. Hedberg, presented by him at the XIXth International Geological Congress and offered as a basis for discussion to those interested in the problem. As one of these premisses appears the assertion that "The classification of rocks into various kinds of stratigraphic units, the hierarchical ranking of such units, and the naming of the units are essentially procedures of convenience" and that "In some respects they may be looked upon as barren and unproductive exercises necessitated only by the limita-

tions of the human mind."<sup>3</sup>

The acceptance of such tendencies would promote the growth of a purely subjective and arbitrary attitude in the treatment of stratigraphic sections and would lead to a loss of historical perspective and to mistakes in the methodology of stratigraphic research.

The distinguishing of stratigraphic subdivisions ought as far as possible to be stripped of elements of subjectivity and arbitrariness. It ought not to proceed from the extremely unsteady and conditional principle of utility and convenience but to pursue the aim of discovering as objectively as possible the actual course of geologic history. Stratigraphic subdivisions ought to be distinguished in such a way that they correspond to real historical steps in the geologic development of the Earth as a whole or of its separate regions. For this they ought to be based on the totality of all the evidence objectively reflecting steps in the historical course of development of the Earth and the special characters of these steps in different regions.

Proceeding from this principle, it is necessary to choose criteria for the delimitation and taxonomy of stratigraphic subdivisions.

The system of stratigraphic subdivisions ought to reflect the natural steps of the historical-geological process and to be based upon the data of inorganic and organic evolution. The first of these is connected above all with the principal steps in the structural development of the Earth's crust, the periodicity of pulsatory movements, transgressions, and regressions, with successive changes in the physical-geographical conditions, and the second with variation, evolutionary progress, migration, extinction, and in general with the historical changes in the development of the organic world.

As far as the evolution of the organic world, its tendencies, tempo, and conditions

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<sup>3</sup> Hedberg, H. D., 1954. Procedure and terminology in stratigraphic classification: XIXth Internat. Geol. Cong. Comptes rendus. fasc. 13, p. 206.

are found in intimate and determinate dependence on the condition and the direction of development of the non-biological factors of the environment, physical phenomena (tectonic movements, historical changes in the relation of land and sea, changes of facies conditions, epochs of volcanism, etc.) ought to have paramount importance in determining at least the principal stratigraphic boundaries, the stratigraphic classification as a whole. Nevertheless practically in most cases in stratigraphy we use not these phenomena, which constitute the original basis of geologic periodicity, but the changes that depend on them in the composition of the organic world -- paleontologic data. The reason for this is entirely comprehensible: the factual documents of the irreversible evolutionary process in the organic world are so numerous and so manifold and at the same time so clear and comprehensible that paleontologic data will always compose the most accessible basis for relative chronologic and stratigraphic correlation. Paleontologic data play an exceptional role especially because they reflect particular steps in the development of organic life on Earth, having been conditioned by the whole course of its development and by the special characters of this development in appropriate periods of time and in appropriate places.

From what has been said above concerning the principles and basic criteria of stratigraphic classification, it is clear that any of the subdivisions of the stratigraphic scale -- from the very large and general to the very small and even more the very local -- ought to correspond to a definite natural step in the general course of development of the Earth and of the fauna and flora that populate it, either in general or to some part or other of the development.

The course of the historical development of the Earth, however, is very complex and diverse.

Aside from general regularities, each region, each geological district, differs also in its local characters.

The diversity and the possible combinations of these special characters is definite. Infinite, consequently, is also the diversity of specific columns of strata, which appear to express this geological process in all its local characters.

For the designated reasons, stratigraphic subdivisions of different ranks have different geographic extent.

In a general view it can be asserted that the higher the rank of the stratigraphic subdivision, the wider its geographic extent, and inversely.

As stratigraphic units of different ranks, in each specific case one distinguishes real geologic bodies, definite assemblages of sedimentary, igneous, and metamorphic rocks composing the Earth's crust, with their material constitution and with all their inherent attributes, relations, and special characters.

From what has been said, a definite conclusion also follows concerning the relation between stratigraphic and geochronologic subdivisions. It must be particularly emphasized that geochronology on a stratigraphic basis is relative geochronology. In contrast with absolute geochronology, based at the present time on radioactive methods of determining the age of rocks, it does not take for its goal the calculation of the length of the history of the Earth and of the separate epochs of that history in absolute units of time -- years, millions and billions of years. Its task consists only in distinguishing the natural steps or stages of geologic history and ascertaining their sequence in time, in determining which of them took place earlier and which later. These very steps of geologic history are distinguished by us only insofar as to them correspond definite assemblages of rocks, distinguished as stratigraphic subdivisions. Stratigraphy and relative geochronology -- these are only two sides of the same coin, and for this reason stratigraphic classification must not be separated from geochronologic classification, neither in its general principles nor in its particular details.

Nevertheless, it is necessary to have two independent scales equivalent to one another: the geochronologic and the stratigraphic. The geochronologic scale is the scale of relative geochronologic time. The compass and sequence of its individual periods are defined by the corresponding historical steps in the development of the Earth in its regular sequence and inter-

connections.

The stratigraphic scale represents the specific expression in sequence of the elapsed events of Earth history, materialized in the corresponding intervals (segments) of columns of stratified rocks and the organic remains entombed in them.

Any stratigraphic subdivision appears to be synchronous and "chrono-stratigraphic." To any stratigraphic subdivision corresponds the equivalent geochronologic subdivision, but its chronologic significance may be either general or local, depending on the general or local significance of the corresponding stratigraphic subdivision.

The possibility of dividing the history of the Earth as a whole or of its separate regions into definite natural steps is determined by the more or less clearly expressed periodicity and irreversibility of the phenomena that took place in the geologic past. The clearest and most general expression of this periodicity appears to be the alternation of long-continued epochs of slow and gradual evolutionary development and relatively more short-lived epochs of significantly more rapid qualitative transformation in the face of the Earth, at a time during which took place a great rearrangement of the internal structure of the Earth's crust and of the physical-geographical environment of its surface. The alternation of such epochs of evolutionary and revolutionary development in this or that form is acknowledged at the present time by the great majority of geologists in every country of the world. Regularly connected with it also is another clear manifestation of periodicity in the historical development of the Earth, the alternation of epochs of predominant sinkings of vast areas of the Earth's surface with epochs of predominant uplifts of equally vast areas, epochs of large transgressions and regressions of the sea. This periodicity in the tectonic history of the Earth's crust and the changes in the physico-geographical environment connected with it are reflected in varying degree and in different form in the well-known periodicity of the majority of other geological processes and phenomena, among their number also the evolution of the organisms populating the Earth. To the major natural steps in the

history of the Earth correspond also basic steps in the flora and fauna, although to be sure this connection appears in very complex forms.

A shift of the different historical-geological steps creates those natural boundaries that are accepted also as the limits of the major stratigraphic subdivisions and the corresponding items of the geochronologic scale.

In this way the separation of the subdivisions of the stratigraphic and geochronologic scales is based on the groupings of rocks in chronologic assemblages following one on another, reflecting the objective course of the historical process of development of the Earth. Basic for distinguishing the units of the geochronologic and stratigraphic scales appear to be, in the present state of our knowledge, the criteria reflecting the character and scale of the following closely interconnected phenomena:

1. tectonic movements of wide geographic range;
2. paleogeographic changes, expressed in changes in the distribution and outlines of land and sea, the relief of the land and sea bottom, the climate, etc.
3. changes in the process of sedimentation and denudation;
4. manifestations of igneous activity and processes of metamorphism;
5. changes in the course of evolution of the organic world (flora and fauna).

All these phenomena represent only different sides of a single process of development of the Earth. To each of them belongs also its particular well known periodicity. But at the same time, to each belongs also its particular irreversibility, so that two analogous events occurring at different times never happen identically, neither in the same way nor with the same results, and, once, past, a step in development can never be exactly repeated anew. The irreversibility is expressed particularly clearly in the evolution of fauna and flora. Each successive step of this history is so individual and unrepeatable that as regards the periodicity in a given case one can

speak only very conditionally. Just for this reason fossil remains of animals and plants appear to be the best indices of the relative geologic age of rocks. Just for this reason in contemporary stratigraphic practice, paleontologic criteria appear to be the most important and the most objective criteria for the distinction and especially for the correlation of the basic subdivisions of the stratigraphic and geochronologic scales, and the character and scale of the changes of fauna and flora serve as the principal basis for determining the taxonomic rank of the stratigraphic units, their "hierarchical" intersubordination.

Extremely important also appears to be the fact that the main steps in the development of the organic world, in virtue of the great capacity of organisms for colonization and migration, are quickly displayed all over the Earth's surface and replace one another practically simultaneously and in one and the same sequence. This creates the major stratigraphic subdivisions, distinguished in a biostratigraphic way, a reliable standard for the accordance of local stratigraphic scales in the various regions of the Earth. In other words, paleontologic criteria appear to be the most significant for working out the stratigraphic and geochronologic scale. They help above all in the solution of the basic problem of stratigraphy -- the creation for the entire surface of the Earth or the major part thereof of a unified stratigraphic scale or a scale of relative geochronology. An exception is constituted by the ancient Precambrian succession, in which the remains of organisms are not as a rule preserved in usable form for study.

Changes of fauna and flora are intimately connected with changes of the environment of life, which appear to be the basic factor in the evolution of the organic world. This connection appears to be a firmly established fact and has found its theoretical basis in particular in the formulation by V. O. Kovalevsky of the law of adaptive radiation. Just for this reason the stratigraphic boundaries established biostratigraphically are as a rule more or less close to the stratigraphic boundaries established on the basis of lithologic or other peculiarities, expressing changes in the environment of life. Such regularity is displayed, with some exception, both as

regards the major stratigraphic units of general importance and in the smaller and more local stratigraphic subdivisions.

The irreversibility of the development of the inorganic world in the history of the Earth is expressed very much less clearly than the irreversibility of the evolution of fauna and flora. Hence results the well known fact that we do not as yet possess "guide rock types" or "guide mineral assemblages" etc., which would serve as universal and reliable indices of age, as guide fossil organisms do. For this reason not one of the criteria enumerated above can compare in its importance for stratigraphy with paleontologic criteria.

At the same time, the various physical, for the most part petrologic, characters of rocks acquire an often essential and now and then decisive importance for the subdivision of the strata of different regions. This occurs particularly in regions with a development of sedimentary, volcanic, or metamorphic successions showing strong facies changes but weakly or not at all characterized paleontologically. The physical characters of rocks acquire the greatest importance in the distinction of local auxiliary units of lesser rank, which are particularly important as a basis for the solution of specific problems of structural geology, geologic mapping, and exploratory work in various districts (regions).

Nevertheless, all these auxiliary local stratigraphic units ought to be formed according to the same basic principles as the general stratigraphic and geochronologic classification.

The working out of a correct theoretical basis of stratigraphic classification and the creation of a unified, general stratigraphic scale for all countries, and also of a terminology and nomenclature, possesses very great scientific and practical importance and at the present time appears to be an urgent task for the geologists of all countries.

This is all the more important because in regard to stratigraphic classification there exists at the present moment a whole series of different discordant and partly incorrect, contradictory conceptions (schemes).

# INTERDEPARTMENTAL STRATIGRAPHIC COMMITTEE, USSR

Some geologists in the USSR and in other countries consider that it is necessary to have not one general (unified) stratigraphic scale but at least two (general or international and local or regional) or three (general, provincial, and local). In the United States for instance three basic scales are accepted: (1) rock-stratigraphic, (2) biostratigraphic, and (3) time (chronostratigraphic), and moreover a whole series of factual stratigraphic scales, equal among themselves, which are distinguished on the basis of separate, arbitrarily selected characters: (1) on authigenic or fragmental minerals; (2) on chemical composition; (3) on the color of the rocks; (4) on cycles of sedimentation, etc.

It is impossible to agree with this. A unified stratigraphic scale ought to be accepted, based on the complex of historical-geological principles, on the distinction of definite steps in the history of the geological development of the Earth, and not on separate, arbitrarily selected characters of the rocks.

Stratigraphic subdivisions are objective categories reflecting real steps in the geological development of the Earth as a whole or of its separate regions, and not artificial conventional conceptions, as sometimes held. Each stratigraphic unit represents an assemblage of sedimentary, volcanic, or metamorphic formations, or combinations of these, corresponding to a definite step in the development of the Earth or of a particular region.

Soviet geologists consider that the unified stratigraphic scale ought to comprise the following intersubordinated units of different geographic scale, as was accepted by the VIIIth International Geological Congress in 1900.<sup>4</sup>

Stratigraphic subdivisions	Geochronologic subdivisions
1 Gruppya - Group	1 Era - Era
2 Sistema - System	2 Period - Period
3 Otdel - Division	3 Epokha - Epoch
4 Yarus - Stage	4 Vek - Age
5 Zona - Zone	5 Vremya - Time

Stratigraphic and geochronologic subdivisions, as recommended also by the International Congress, ought to be distinguished in independent scales, in which the stratigraphic subdivisions refer to strata while the corresponding geochronologic subdivisions refer to temporal steps in the development of the Earth and its organic world. The interrelation of one and the other scale is shown in the above table.

In regions and districts of complex constitution, which cannot with sufficient definiteness be assigned to units of the designated unified stratigraphic scale, or in districts still insufficiently studied, local (regional) stratigraphic assemblages ought to be distinguished, to be used for geologic mapping and for other particular goals. Similar subdivisions can be distinguished for separate less well studied intervals in the stratigraphic column.

For the designation of such assemblages it is recommended to accept the following auxiliary local (regional) stratigraphic subdivisions, in order of subordination:

- (1) Seriya - series
- (2) Svita - suite
- (3) Podsvita - subsuite
- (4) Pachka - packet

The auxiliary local subdivisions ought without fail to be connected with the subdivisions of the unified scale.

In this way, a specific stratigraphic scheme for any region will be put together out of the subdivisions of the unified scale and auxiliary subdivisions. The subdivisions of higher rank (stage and higher) will generally appear as subdivisions of the unified scale, the lower ones as auxiliary local subdivisions.

<sup>4</sup>Commission Internationale de Classification Stratigraphique, 1901, Rapport par E. Renevier: VIIIth Internat. Geol. Cong. Comptes rendus, fasc. 1, pp 201-203. This table differs from

the recommendations of the Congress in certain respects, however. In the first column, no term was recommended for item 1 (though group has been recommended by the 2nd Congress in 1881), and Series was recommended for item 3 rather than Division (the Russian word for Series appears on the table of auxiliary local subdivisions, beyond). In the second column, Phase was recommended for item 5, but it was not widely used (see beyond under Zone). Note by J. R.]

In each separate case, therefore, stratigraphic division will proceed in units of the unified scale only to that point, to that level, which is objectively possible. Sometimes this will be system or division, more often stage. Smaller subdivisions will mostly appear as auxiliary local units (suite, etc.).

The combination of the "unified" scale and the "auxiliary" subdivisions in each particular case will be achieved by subordinating the auxiliary unit that is highest in rank of those used in the given case to the smallest possible subdivision of the unified scale: for example, group, system, division, stage, suite, packet, or group, system, series, suite, etc.

Aside from the stratigraphic subdivisions enumerated above, one can use subdivisions of intermediate rank with the prefix "nad" (super-) for units of a higher and the prefix "pod" (sub-) for units of a lower category than the named unit (for instance, subdivision, substage, etc.).

In regard to stratigraphic names, it is indispensable to make use of the principles of priority, analogous to those adopted in biological nomenclature.

For each newly distinguished stratigraphic unit, there ought to be a fixed and designated stratotype.

In the large majority of cases, stratigraphic subdivisions have been established and will be established empirically and partly on incomplete (limited) material, so that in the process of further more profound and many-sided study not only in precision and some change in the original general character of any stratigraphic subdivision possible, but also some precision and change in its extent and boundaries.

What follows refers only to the stratigraphic scale. It is not necessary to dwell here on the geochronologic scale.

#### SUBDIVISIONS OF THE UNIFIED STRATIGRAPHIC SCALE

The largest stratigraphic subdivisions, those common to the present continents, are group, system, and division.

#### Group

The deposits represent the largest subdivision of the unified stratigraphic scale, formed in the course of one era. It unites several geologic systems, among which an intimate connection exists as regards tectonic movements, igneous activity, sedimentation, and the development of the organic world. Groups in general reflect the largest steps in the development of the Earth and its organic world. They ordinarily show at their boundaries evidence of tectonic movements that were extremely strong and large-scale in the history of the Earth (orogeny, general continental uplifts and, connected with them, the most important regressions on the platform, displays of igneous activity), as a result of which the sizes, configurations, and distribution of land and sea, the relief of the Earth's surface, etc., abruptly changed.

At the present time, the following groups are distinguished: Archean, Proterozoic, Paleozoic, Mesozoic, and Cenozoic. The names of the groups reflect their relative antiquity and correspond to the most important steps in the development of the Earth. Correlation within the two oldest groups -- Archean and Proterozoic -- is established above all on the basis of their structural-geological peculiarities (great, regionally expressed angular unconformities, particularly differences in the extent of systems of folds or folded zones), the relative development of rocks of sedimentary and igneous origin, the wide spread and intensity of phenomena of regional metamorphism and of phenomena of granitization.

The Paleozoic, Mesozoic, and Cenozoic groups differ essentially from the Archean and Proterozoic because in establishing them already a large role is played by major changes in the composition of the organic world (down to classes and orders). The most important special character of the Paleozoic, Mesozoic, and Cenozoic, the one that is new in principle, appears to be the exceptionally wide extent of epicontinental (platform) seas, which together with the regional belts of geosynclinal seas proved particularly favorable for the rapid development of organic life.

# INTERDEPARTMENTAL STRATIGRAPHIC COMMITTEE, USSR

## System

The system consists of deposits composing part of a group, i.e. appearing as a unit of the second rank of the unified stratigraphic scale and formed in the course of one period. Systems unite the deposits of three or less often two divisions, which within the system ordinarily correspond to three or two successive steps in the development of the chief transgressions and regressions, i.e. they appear to be the expression of the major pulsatory movements of the Earth's crust.

In the columns of systems, there ordinarily predominate at the beginning, i.e. in the lowest division, deposits formed partly under continental conditions that continued on from the end of the preceding period, and partly under conditions of a new marine transgression. Generally characteristic for the upper division of the system are deposits corresponding to the completion of the marine transgressions and to the regressions that follow, caused by extensive regional uplifts timed to the boundaries of the period. These general regularities in the patterns of systems may to one or another degree (sometimes entirely) break down or become complicated or modified, showing important local complications or deviations in different regions.

At the boundaries of adjacent systems or near them are often observed angular unconformities, stratigraphic breaks, abrupt changes in fauna, evidence of intensive igneous activity. These phenomena have wide geographic extent, but they by no means appear to be universal.

Systems are characterized by families and genera of great vertical extent in the fauna and by genera and species in the flora, which are distinctive only for the given system or there show predominant and typical development. Of basic importance for the practical demarcation of adjacent systems is the substantial renovation of the marine fauna, expressed in the appearance and wide development of new groups of major systematic rank (genera, families, etc.).

Changes in the composition of the fauna and flora are closely connected with the tectonic and paleogeographic changes designated above.

The names of the systems have different origins, as they were introduced by various investigators and at different times (from 1822 to 1879). As historically composed, the names of the majority of systems correspond to the ancient or present name of the locality in which they have first distinguished (Cambrian, Devonian, Permian, Jurassic) or to the ancient nation that inhabited that locality (Ordovician, Silurian); other systems are named either for particular characteristics of the type strata (Carboniferous, Cretaceous) or for the special characters in their construction in the type locality (Triassic) or for their position in order in the first scheme of subdivisions of the deposits of the Earth's crust (Tertiary, Quaternary).

## Division

The division consists of deposits composing part of a system, i.e. representing a unit of the third rank of the unified stratigraphic scale and formed in the course of one epoch.

In conformity with the general course of tectonic (pulsatory) movements taking place in the course of a period, the common number of divisions in the majority of systems is three. In those few systems within which the most substantial changes in the physical-geographical conditions and in the composition of the deposits and of the fauna are placed roughly at the middle of the system, only two divisions are distinguished (for instance, in the Cretaceous system). The divisions include the deposits of the several (two or more) stages that compose them.

Divisions are characterized by the presence of relatively major systematic groups of fauna and flora (subfamilies, genera, etc.) distinctive only for them or typical of them in their predominant development, though essential changes (renovations) in the content of the flora often take place sooner than in the content of the marine fauna.

The faunal content of the deposits of different divisions of each system and the relation of these deposits both within the divisions and at their boundaries reflect above all the common special characters of the geologic history of the various epochs.

Both within divisions and especially at their boundaries are often included angular unconformities, more or less abrupt changes in fauna, and other characters connected with various tectonic movements and also products of diverse igneous activity. In spite of this, evidences of major breaks in sedimentation within and at the boundaries of divisions ordinarily have more restricted extent than at the boundaries of systems.

The common faunal special characters of the deposits of divisions reflect the same tectonic and paleogeographic special characters with which are connected also the above-mentioned significant renovation in the organic world of the corresponding epochs.

The last appears, particularly as regards the content of the marine fauna, to be the basic criterion for the delimitation of divisions.

Divisions of the Quaternary system generally comprise sediments formed as the result of the series of glaciations and interglacials, and the synchronous deposits of extra-glacial regions and marine basins. Adjacent divisions of this system are bounded by evidence of abrupt changes in the physical-geographical conditions of land and sea.

The names of the divisions are given to correspond to their relative position in the scale, i.e. lower, middle, and upper for the divisions of systems with a threefold division, lower and upper for the divisions of systems with a twofold division. Sometimes, however, divisions are given particular names, for instance Lias, Dogger, Malm, etc., or names from stages in the development of the organic world: Pleistocene, Holocene.

#### Stage

These deposits represent a stratigraphic subdivision forming part of a division, i.e. a unit of the fourth rank of the unified stratigraphic scale. A stage corresponds to a definite step in the geological development of the Earth or a significant part of it. The compass and boundaries of a stage are defined by a grouping of geologic and paleontologic data, reflecting the corresponding epoch in the develop-

ment of the Earth and of its organic world. The last is expressed by the presence in the deposits of a stage of index assemblages of fossil remains of organisms with genera, subgenera, and groups of species typical for the given stage and peculiar only to it.

As stages, as a rule, ought to be distinguished units of extremely wide or universal extent, based on assemblages of geographically widely distributed organisms (foraminifers, graptolites, cephalopods, etc.), taking into account the periodicity of accumulation of the sedimentary successions. To an already established stage, therefore, are referred not only deposits with the typical assemblage of the stratotype of the given stage but also deposits with other assemblages, if their synchronicity with the first can be established by the presence of common allied forms or by way of precise stratigraphic comparisons.

In the deposits that, because they belong to particular biogeographic provinces, are not accessible to precise comparison with stages widely distributed on the Earth's surface, one may distinguish as a stage a combination of deposits corresponding in turn to a definite step in the geologic development of the given province, in the first instance of its fauna and flora. In the majority of cases, such stages will correspond more or less in their compass to stage-subdivisions of deposits widely distributed on the surface of the Earth.

It is quite inadmissible to distinguish as new stages temporary preliminary units of the local stratigraphic scale, liable in the future to be replaced by some other stages of already established schemes.

In establishing new stages, it is necessary to show that the deposits forming it do not belong to previously established stages but roughly correspond to them in rank, representing a particular step in the geological evolution of a large territory. The paleontologic assemblage of the stage being distinguished ought to be adequately distinctive and on the whole to differ abruptly from the assemblages of the adjacent stages. In distinguishing a new stage, it is possible to refer to it

part of the underlying or overlying deposits of preexisting stratigraphic subdivisions on account of reexamination and reduction in the compass of those subdivisions, but in this case analysis of the column in the region of the original stratotype is obligatory.

In the Quaternary system, as a stage one may distinguish sediments corresponding ordinarily to a single glaciation or interglacial. The boundaries of such stages are defined by the character of those changes in the content of sediments and organisms that are connected in principle with changes in climatic conditions during this time, with the development of the organic world, man, and his material culture.

The names of stages are derived from modern or ancient geographical names of regions or districts in whose territory are developed the typical sections (stratotypes) of the given stage.

For the designation of the time, in the course of which the accumulation of the deposits united in the stage took place, the term "age" is used.

## Zone

These deposits represent a subdivision of the fifth rank of the unified stratigraphic scale and form part of a stage.

Its compass and boundaries are defined by the limits of the extent of a definite grouping of widely distributed and preferable rapidly changing organisms, constituting the zonal faunal (or floral) assemblage, which is not repeated either in the overlying or in the underlying deposits. Into the content of each zonal assemblage ought to enter as far as possible all the stratigraphically most important groups of fauna (flora) represented in the given deposits.

The extent of a zone embraces generally a whole biogeographic region or province, less often a significant part of the latter; sometimes a zone can be extended also through two or even several regions or provinces. To a zone, distinguished in the deposits by this or that faunal content, may be added also deposits contemporaneous with it but of different facies, which are interbedded with paleontologically characterized deposits of the zone or

directly replace it in its range.

The name of a zone<sup>5</sup> is given, as a rule for the most characteristic guide form (species) out of the content of the guide-zonal assemblage, but the name is preserved even for those districts where, in the content of the zonal assemblage accepted for the name of the zone designated above, the zonal species -- the index -- is not found. In general, the body of the guide zonal assemblage in different regions may indeed change on account of the dropping out of some characteristic species and the appearance of new local elements. Nevertheless, ordinarily the general character of the zonal assemblage is preserved, and the presence of the one or two most typical species along with allied or substitute forms often permits tracing a zone over extremely important districts.

For deposits that are more or less contemporaneous but belong to sharply different biogeographic provinces (especially if these deposits are developed in geographically widely separated regions) or for successions that are sharply different in facies and stratigraphically not directly connected (especially for subdivisions of synchronous marine and continental deposits), separate schemes of zonal division can be applied.

One should not confuse zones with the so-called biozones representing deposits formed during the whole time of existence of some one characteristic or guide species, genus, family, or larger systematic unit of animals or plants.

There is no universally accepted term that designates the duration of the time of deposition of the sediments of a zone; ordinarily the term "time" is here applied, along with the name of the zone placed in quotation marks (for example, time of "Manticoceras intumescens").

## AUXILIARY (LOCAL) STRATIGRAPHIC SUBDIVISIONS

Long ago already it became clear that

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<sup>5</sup> When necessary, one may introduce into the name of a zone the two or three most typical species, distinctive in the whole region of the extent of the zone or characteristic in various combinations in the different parts of that region.

subdivisions of the general unified scale alone, worked out as a rule on the evidence of one region (Western Europe) or a few regions, were insufficient for the extension of geologic investigations into all the new districts of the Earth's surface. It turned out that for many other districts and regions, these subdivisions are not applicable and cannot be used practically. Particularly this concerns the smaller subdivisions (of lower rank), the natural compass and contents of which, as also the correlation to adjacent subdivisions in various regions, is ordinarily difficult in connection with the different course, tempos, and special characters of the geologic process in different regions and districts of the Earth's surface. One observes in various districts local peculiarities of fauna and flora, special characters of their content, and commonly having such great local differences in the vertical extent of forms (depending on facies conditions, and also on local peculiarities in the course of the geologic process) for synchronous deposits (horizons), that often they do not permit precise correlation of the given deposits with definite subdivisions of the unified scale. More than that, such correlations often prove in general impossible because of the insufficiency or the entire absence of paleontologic or other data.

At the same time, one can always distinguish the district's own local stratigraphic units -- the real geologic bodies here developed, definite assemblages of sedimentary, igneous, and metamorphic rocks, clearly marked off from adjacent assemblages, lithologically easily identified in the field, well worked out and having a sufficiently wide area of extent. Such local stratigraphic units (subdivisions) possess immense practical importance, appearing basic for knowledge of the geological constitution of the corresponding territory. Just in connection with these, long ago already the necessity arose of distinguishing for different regions and countries their own auxiliary (local) stratigraphic subdivisions, i.e. units of restricted geographic extent.

Many consider that auxiliary (local) subdivisions are distinguished and ought to be distinguished on the basis of altogether other principles and criteria than subdivisions of the general (unified) scale,

that they appear to be purely lithologic units and ought for this reason to be based on lithologic criteria alone.

All other criteria, i.e. their complex totality, all groupings of other evidence in the given case are for some reason or other considered unnecessary and rejected.

Thus is constructed, in particular, the scale of local subdivisions officially accepted in the USA<sup>6</sup>, which is even called the rock-stratigraphic scale, and all its subdivision ("group," "formation," etc.) in the judgment of the American Stratigraphic Commission (Hedberg) do not in general appear to be geologic age conceptions, for they are based on objective physical data and their age and the interval of time corresponding to them can change from place to place, as much as an entire geologic period.

The designated premisses appear to be mistaken and cannot be accepted. In particular, it must be observed that precisely because the "rock-stratigraphic" subdivisions appear to be material units, because they represent real objectively existing geologic bodies, they cannot avoid being also at the same time age categories.

From a correct premiss, that the limits of a formation and other lithologic subdivisions can intersect age boundaries, has here been drawn a false conclusion, that these subdivisions in general are not temporal.

The principles and criteria for distinguishing all stratigraphic subdivisions are one and the same. In this regard, auxiliary (local) subdivisions in no way differ from subdivisions of the unified stratigraphic scale and, just like the latter, ought to be based on every grouping (assemblage) of special characters, of attributes, and of geologic relations appropriate to the deposits, and also on the fauna and flora.

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<sup>6</sup> Report of a special stratigraphic commission under the chairmanship of Hedberg (1952). [American Commission on Stratigraphic Nomenclature, 1952, Report 2--Nature, usage, and nomenclature of time-stratigraphic and geologic time units: Am. Assoc. Petroleum Geologists Bull., v. 36, p. 1627-1638.]

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As auxiliary (local) subdivisions are distinguished those natural assemblages (groupings) of deposits, those natural material geologic bodies, that occupy a definite position in the column and that by the grouping of their properties (lithologic, paleontologic, and other characters) are sufficiently definitely and permanently distinguished from all other such assemblages or bodies.

Each such subdivision corresponds to a definite step in the development of the corresponding portion of the lithosphere, occupies a definite stratigraphic position, and is distinguished from the adjacent subdivisions by more or less clear natural limits, accepted as the boundaries of the subdivisions.

In many cases, such subdivisions correspond to major local cycles of sedimentation, the boundaries of which are then accepted also as the boundaries of the corresponding stratigraphic subdivisions.

Auxiliary (local) subdivisions are distinguished only in those cases where, because of the absence of insufficiency of fauna and flora in the given district (region), the universally accepted subdivisions of the unified scale cannot be established, or the compass and boundaries of the latter sharply fail to coincide with the natural compass and boundaries of the local stratigraphic assemblages.

As auxiliary, local (regional) units are accepted the following intersubordinated stratigraphic subdivisions: series, suite, subsuite, packet. Besides that, the special subdivision "horizon" is likewise accepted, uniting in the area of a given region or of two or three adjacent regions several clearly contemporaneous suites.

### Series

The series is the largest unit among the auxiliary, local (regional) stratigraphic subdivisions, embracing a thick succession, complex in its content, of sedimentary, volcanic, or metamorphic formations (or a grouping of those and others), often corresponding to a single major sedimentary, volcanic, or tectonic cycle.

Within themselves, series are ordinarily

divided by important stratigraphic and angular unconformities, and often (in geosynclinal districts) by phenomena of igneous activity in intrusive form. The extent of a series ordinarily embraces major regions of more or less homogeneous geologic constitution, though separate parts of a series can be geographically disconnected. In other words, the unification of strata in a single series can be produced not only on the basis more or less of a unique geologic section, but also on the basis of comparing the smaller units composing it -- of the suites, which are observed in different parts of a large region.

A series is divided into suites and ought to have a particular geographic name. If necessary, several non-contemporaneous adjacent series (successive in time) can be united together, but such a combination of series is ordinarily designated as a "complex" to which also is assigned a particular geographic name.

In its own compass, a series ordinarily corresponds more or less closely to a division of the general scale, but it can also be larger or smaller than the latter. In conjunction with the unified scale, a series can be subordinated to a division or a system.

### Suite

The suite is the basic unit among the auxiliary stratigraphic subdivisions. In its horizontal extent, it is restricted by the limits of a definite structural-facies zone or district with more or less uniform conditions for the formation of sediments.

A suite represents by itself a combination of deposits formed within the limits of a given region under definite physical-geographical conditions and occupying within it a definite stratigraphic position. It is distinguished on the basis of every grouping of the same characters on which also the subdivisions of the unified scale are distinguished; nevertheless a suite may be distinguished also in the absence of some of these characters, in particular in the absence or insufficiency of fauna and flora.

In the latter case, a suite is distinguished on the basis of lithologic and other

characters. An extremely careful search for and collection of organic remains (macro- and microfauna, macro- and microflora, spores, and pollen) is however obligatory in all cases.

With the conception "suite" ought to be connected internal unity (in conditions of formation, content of sediments, in fauna and flora, stratigraphic correlation, metamorphism, etc.). A suite can consist entirely of homogeneous rock or, maintaining a predominance of one rock, it can include layers of others, or, finally it can be characterized by a heterogeneous content.

A suite can be composed either of sedimentary or of volcanic formations or of the two combined, and also of metamorphic formations.

Besides its own stratigraphic position, a single suite ought to be clearly distinguished from others either by every grouping of characters or at least by facies-lithologic special characters or paleontologically, and in any case the boundaries between suites ought to be sufficiently clear. For the delimitation of adjacent suites, natural boundaries ought to be used, expressed in substantial facies-lithologic changes with marked changes of fauna and flora, and sometimes also in stratigraphic breaks, angular unconformities, etc.

Different suites may rest one upon another either conformably or unconformably. Within a suite there may not be substantial stratigraphic or angular unconformities, though evidence of small breaks in the form of layers of conglomerates, surfaces of erosion, dropping out of insignificant parts of the column, etc., also may occur within a suite.

The temporal extent of a suite, i.e. the duration of formation of its sediments, is determined from paleontologic data. In the absence of organic remains within it, the age of a suite is defined by the age of the underlying and overlying deposits. Finally, the age of a suite can be established conditionally by comparing the columns of the given region with nearby regions or districts, where the temporal position of the corresponding interval of the column appears to be more or less definite.

In its compass, a suite mostly corresponds to a significant part of a stage, sometimes even approximately to a whole stage or even several stages. In rare cases, for the most part for older formations, a suite may encompass a whole division or significant parts of one or two adjacent systems. The boundaries of a suite often do not coincide with the boundaries of any subdivision of the unified stratigraphic scale; in this case, the suite includes in itself partly or wholly the strata of two or three adjacent subdivisions of the unified scale.

A suite ought to be distinguished by a sufficient geographic consistency of its basic characters, in particular the facies-lithologic ones. Within the limits of the given structural-facies zone or region, to one and the same suite ought to be referred also deposits synchronous with it, differing from the stratotype, if they preserve the same general appearance.

The age of a suite as a whole ought to be approximately the same in the whole area of its extent, although its upper and lower temporal boundaries can all the same be somewhat different in different portions of the development of the suite.

If different parts of a suite, despite its general unity, possess all the same their own sufficiently definite and constant special characters, the suite may be subdivided into two or three parts, called subsuites.

In distinguishing a new suite, one ought without fail to establish at least an approximate, sufficiently proved correlation of it with the subdivisions of the unified scale. Besides that, the arguments ought to be given concerning the correlation of the newly established suite with contemporaneous suites of neighboring districts. Where possible, the paleontologic facies-lithologic and other special characters distinguishing it from earlier established suites should be clearly defined. Without fail, the stratigraphic relations of the new suite with the underlying and overlying suites in the same region should be designated.

A suite may not be distinguished by a

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new name if the deposits composing it in approximately the same stratigraphic limits and the same region were already distinguished earlier by someone under particular names as particular suites or other stratigraphic units of the local scale (independently of what original interpretation was given of this unit in regard to its stratigraphic position or geologic age).

A suite should without fail have a particular geographic name, which ought to be different from the names of other suites of different age and geographic extent. In spite of this, it is not permitted to name as suites local stratigraphic subdivisions that are distinguished as temporary stratigraphic units in the process of exploration and where the special characters are not examined over a sufficiently large territory. For such subdivisions geographical names are permissible but in combination with the word indicating their lithologic content (for example, Kiev marl, Petrov sandstone, Mikhaylov limestone, etc.), or with the word beds and other words of informal usage.

The name of a newly established suite may be introduced into geologic literature only after the publication of its full diagnosis in the Bulletin (Annual) of the Stratigraphic Committee or in other periodical geological publications.<sup>7</sup>

### Subsuite

The subsuite is an auxiliary stratigraphic subdivision, representing in itself a large part of a suite.

In spite of general unity with the other parts of the suite, it possesses all the same its own sufficiently definite and constant special characters.

Subsuites are distinguished one from another by clearly marked paleontologic or lithologic characters, reflecting local and secondary physical-geographical changes and changes of the organic world. The combination of subsuites constitutes the whole suite.

There should not be substantial stratigraphic breaks and angular unconformities between subsuites. Subsuitses ought to possess consistency of their special characters over more or less significant areas.

Subsuites are called lower, middle, and upper, along with the name of the suite; for example, "lower Balakhon" subsuite, "upper Balakhon" subsuite, etc.

### Packet

The packet is a relatively minor part of a suite or subsuite, characterized by definite, facies-lithologic special characters. The areal extent ordinarily appears to be limited.

A packet is designated by number or letter indices along with the lithologic name in parentheses in the nominative case: for example, packet 5 (gray marl). The numeration of packets proceeds successively from below upwards (in the column): 1, 2, 3, 4; or a, b, c, d, etc.

A packet not having a number or letter index can be used as a word of informal usage. For example, the packet of variegated clays, the coal-bearing packet, etc.

### Horizon

The horizon is an auxiliary unit of local (regional) significance, uniting along the horizontal (over an area) several contemporaneous suites (or parts of them) or deposits of different facies in various districts but undoubtedly synchronous one with the other, corresponding approximately in rank to a suite or to a zone of the unified scale. A horizon is distinguished by a combination of lithologic and paleontologic characters for regions where because of the state of study or for other reasons zones cannot be distinguished.

A horizon ought to possess a geographic name and a stratotype.

## SPECIAL CHARACTERS OF THE STRATIGRAPHIC AND TEMPORAL SUBDIVISIONS OF IGNEOUS FORMATIONS AND THEIR NOMENCLATURE

In the stratigraphic division of effusive formations and tuffs a series of difficulties

<sup>7</sup>Inadmissible are names of suites with the prefixes "sub" and "super", for instance "super-Altai", "sub-Kemerov", etc.

are encountered: (a) the rare occurrence or absence in them of organic remains, (b) the rapid variability of suites in composition and thickness, (c) the unclearness of occurrence of effusives and tuffs, (d) the presence in them of dikes, stocks, and hypabyssal intrusives, and also of hydrothermally altered rocks, distinguished with difficulty from the effusives, (e) commonly the monotonous composition of volcanic rocks over the extent of stages, divisions, and even larger subdivisions, despite the great difference in composition and structure of rocks of separate layers and packets and the rapid variability over an area.

In the stratigraphic division of volcanic successions, for this reason, one often is forced to have recourse to auxiliary (local) subdivisions. The basic principle of distinguishing volcanic suites is the same as for sedimentary rocks; a suite ought to correspond to a definite step in the development of the given portion of the Earth's crust. For this, along with those characters that are used for the subdivision of sedimentary deposits, it is necessary to take into account the special characters of the development of the volcanic cycle and the regularities of evolution of the composition of volcanic rocks.

In the division of volcanic successions, the practically important significant points are: (1) stratigraphic unconformities within the succession, which are very common for them, because the formation of these successions ordinarily proceeds in zones of intense tectonic movement; (2) evidence of a break, of extinction and renovation of volcanic activity; (3) typical regularities of the construction of these successions; (4) petrographic and petrochemical special characters; (5) special characters of their metamorphism, in particular autometamorphism.

Intrusive rocks, through evidence of interconnection with definite stages of tectonic activity and through genetic relationship between themselves, are united into intrusive assemblages.

Rocks of one intrusive assemblage display a series of geologic, petrochemical, mineralogic, geochemical, and metallogenetic special characters, indicating their origin from one and the same magmatic

hearth. They were formed in a relatively short interval of time, being connected either with a definite period of folding or with the appearance of a definite system of fault-dislocations. Thus, for instance, the alkaline rocks of the Pambak alkaline assemblage of the Little Caucasus, varying from gabbros and monzonites through diorites, granodiorites, and porphyrites to nepheline and pseudoleucite syenites, break through upper Eocene strata and are overlain by lower Oligocene. Among themselves, intrusive assemblages are as a rule divided by more prolonged intervals of time.

For intrusive assemblages it is proposed to give the age-name with the designated content, and, in case of complexity of content or the presence in a region of several contemporaneous assemblages, to use a geographic name: upper Eocene hyperbazite, upper Eocene Pambak, etc. Only where it is impossible to define the age more exactly and for rough subdivision is it permissible to group assemblages according to cycles of folding.

A grouping of genetically and temporally interconnected igneous formation, composed of effusive rocks, of intrusions breaking through them and close to them in age and sometimes also in composition, and of dikes and hypabyssal intrusions intersecting them, is united under the conception of a volcanic cycle. For instance, the upper Ludlovian-lower Devonian volcanic cycle in the Urals is formed by trachytic porphyries, basaltic and andesitic porphyries with an elevated content of potassium, intrusives of syenite breaking across them, and dikes of monzonitic and shonkinitic porphyries cutting the latter.

A grouping of magmatic formations connected with the development of a single mobile belt (geosyncline) can be united in the conception of a tectonic-magmatic cycle. These cycles are named for the time of appearance of the major folding.

#### SPECIAL CHARACTERS OF THE STRATIGRAPHIC CLASSIFICATION AND TERMINOLOGY OF THE PRECAMBRIAN

Owing to the absence or the uncertain significance of the rare paleontologic discoveries in the successions of sedimentary

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rocks of the Precambrian, tectonic-magmatic or orogenic cycles are used as a basis for its stratigraphic division. Besides this, among the igneous formations intrusions of granite and phenomena of migmatization and granitization, widely distributed in the Precambrian, possess particularly great significance for division. Less often intrusions and extrusions of basic rocks are successfully used for division.

For the division of the Precambrian into groups, the following criteria serve:

1. Stratigraphic and structural unconformities of regional character, in particular discordances in the scheme of construction of folded regions. To the latter belong discordance in the range of younger folded systems in comparison to the range of older systems and the "molding" of young folded structures around older stable blocks.

In this way, onto an original strictly stratigraphic discordance are superposed in these cases structures, the formation of which is connected with the kinematics within orogenic zones.

2. The presence or absence of synorogenic and epiorogenic intrusions of granitoid rocks and of preorogenic and synorogenic extrusions and intrusions of basic rocks (ophiolites).

3. Structural-facies and lithologic special characters. The presence of some characteristic formations.

4. Difference in the grade of metamorphism of the rocks. This character, however, what with the detailed structural division of successions and the construction of isograds, in some cases loses the original significance that was attached to it. In other words, this criterion can be used only partially in view of detailed analysis of the processes of metamorphism.

5. Data on absolute age. Theoretically this criterion ought to possess the most decisive significance for the division of the Precambrian, but the objective possibility of its application (utilization) is still extremely restricted, because of the imperfection of the now existing methods of determining the absolute age of rocks and

the low reliability of the results obtained. The determination of absolute age ought to be pursued in view of this on one and the same groups of minerals and by the same methods.

6. Paleontologic data. This criterion possesses, however, restricted significance, and only for the Proterozoic.

Most decisive appear to be the criteria designated in point 1. The remaining criteria possess restricted, auxiliary significance, and questions of the stratigraphy of the Precambrian ought to be decided only by a combination of them. Hence it is clear what significance criteria of absolute age could possess, if those many obstacles that at the present time hinder their use should be successfully removed.

### Archean group

For the distinction of this group, the following criteria serve:

1. Unconformity with the overlying Proterozoic.

2. The presence of intrusions of ancient granites, migmatization, and granitization, and also of basic extrusions and intrusions of an older tectonic-magmatic cycle or cycles.

3. Predominating extent of rocks of a higher grade of metamorphism, migmatization, and granitization (amphibolite and higher grades of metamorphism).

4. Predominating development of crystalloblastic structures and very rare preservation of the original structures of sedimentary and igneous rocks (paragneisses and orthogneisses).

5. Absolute age.

A general division of the Archean into upper and lower is used, for which the same criteria are used that are designated in points 1-5. All smaller subdivisions of the Archean appear to be local, auxiliary subdivisions: complex, series, suite, subsuite.

### Proterozoic group

For the distinction of the given group,

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the following criteria serve:

1. Unconformity with the underlying Archean and the overlying lower Paleozoic (Eopaleozoic).

2. Absence of intrusions of older granite and presence of younger intrusions, migmatization, and granitization of pre-Paleozoic age.

Presence of younger (post-Archean) cycles of intrusion of basic rocks, particularly for geosynclinal zones.

3. Local migmatization, connected with synorogenic granites. Development of aureoles of contact metamorphism around Proterozoic intrusions, which seldom occurs in the Archean.

4. Predominating extent of lower grades of metamorphism than in the Archean (greenstone facies).

5. Relatively frequent preservation of the original structures of sedimentary and igneous rocks.

6. Absolute age.

7. Organic remains (for the upper Proterozoic).

The same criteria (points 1-7) are used to subdivide the Proterozoic into upper and lower. More detailed division into series, suites, and subsuites is based essentially on structural-facies and lithologic special characters of Proterozoic successions.

### Terminology

The following terminology is accepted.

The Archean and Proterozoic groups are subdivided into upper and lower (or even middle) Archean and Proterozoic, having the significance of subgroups. Nevertheless there is no assurance of the real synchronicity of these subgroups in different regions, and for this reason it is recommended that, in distinguishing in each of them upper and lower Archean or Proterozoic, the corresponding regional name be added; for example: lower Archean (or Proterozoic) of Karelia, upper Proterozoic of Aldan, etc.

Subdivisions smaller than subgroup appear to be already auxiliary, local (regional) subdivisions. Among these, as also done for younger formations, complexes, series, suites, and subsuites are distinguished, having appropriate geographic names.

# Review Section

Rauser- Chernousova, D.M., FACIES OF UPPER CARBONIFEROUS AND ARTINSKIAN DEPOSITS IN THE STERLITAMAK-ISHIMBAEVO REGION OF THE PRE-URALS, BASED ON A STUDY OF FUSULINIDS (FATSII VERKHNEKAMENNOUGO-LNYKH I ARTINSKIKH OTLOZHENII STERLITAMAKSKO-ISHIMBAISKOGO PRI-URALYA (NA OSNOVE IZUCHENIYA FUZULINID)) Akad. Nauk SSSR, Institut Geologicheskikh Nauk, Trudy, Vypusk 119, Seriya Geologicheskaya, no. 43, 108 pp., Moscow, 1951. A review by Maxim K. Elias, Professor Emeritus, University of Nebraska.

Contents:	Pages	
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## ABSTRACT

Rauser-Chernousova's paper on the geology of the principal region of the "Second Baku" oil fields of Russia contains a history of geologic exploration, an outline of pre-Kungurian (Permian) topography, detailed stratigraphy, facies analysis of twelve successive stratigraphic units of the reefs and the surrounding area, and an outline of geologic history and paleogeography. Major and minor cyclicity in sedimentation are described.

The reviewer has appended his own introduction. A structural map of Ishimbaevo oil fields (Fig. 1) and a geologic cross-section of the eastern subsurface reef massifs are added from Trofimuk and Dubrovin (1936) and Shamov (1940), modifying the latter into a pictorial section to show the distribution of the principal reef building organisms (See Fig. 2, p. 42). Many additional references in the bibliography are added in order to indicate the sources where the fossils mentioned by Rauser-Chernousova are described and illustrated, and a list of abbreviations of author's names used by her is appended. An index of terms and

fossil names is compiled.

The reviewer introduces two new terms: facieology, a science of facies; and formation to be used instead of "formation" now used by Russian facieologists, because the old term formation is used in a different sense by non-Russian stratigraphers.

The reviewer's comments on stratigraphy are added to explain the historical development of some Russian stratigraphic terms, and Russian understanding of fusulinid genera from whose names these stratigraphic terms are derived.

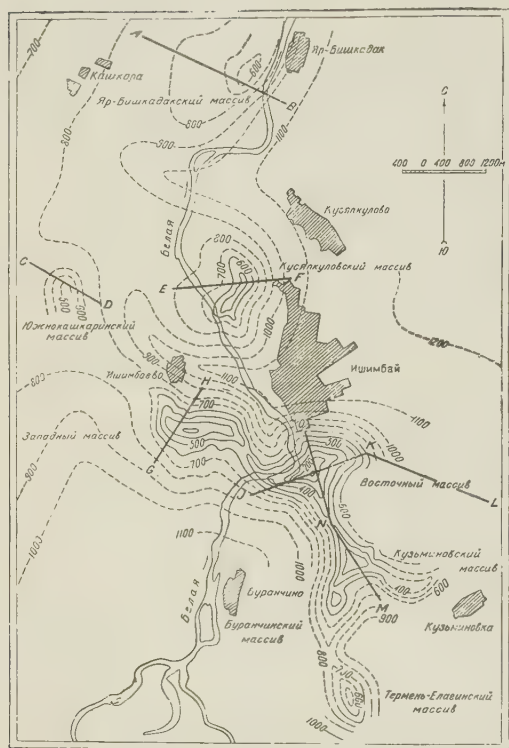


FIGURE 1. Map of subsurface relief of Artinskian limestone massives of Ishimbayev region (After D. F. Shamov, 1940, fig. 1)  
Explanation: Contour intervals 100 meters.  
Hatched areas are population centers. Note two nearly identical geographic names.

The reviewer's paleontological notes explain why (among algae) Maslov's 1956 term Tubiphytes obscurus may be used in place of Rauser-Chernousova's term Shamovella; Girvanella sp. in place of "Blue-Green alga A"; Solenopora (?) cf. spondioides (Dyb) in place of Solenopora ?; siphonaceous green algae in place of Mizzia (correction by Maslov); Pseudo-vermiporella cf. sodalica Elliot in place of "calcareous alga with partitions" (her pl. 3, fig. 4); and, among foraminifera, Ptychocladia sp., n. sp. ? in place of "calcareous alga with partitions" (her pl. 3, fig. 3); and Palaeonubecularia fluxa Reitlinger in place of "Nubecularia".

## Introduction

The Ishimbaevo oil field was discovered in 1932 by A.A. Blokhin, who was in charge of the drilling in an area about 20 kilometers southeast of the village Sterlitamak.

Scores of core-drilled boreholes subsequently penetrated the Upper Carboniferous-Lower Permian reefs, their initial production of oil induced the naming of the new oil-field "Second Baku" (Gubkin, 1940).

The essay by Mrs. Rauser-Chernousova was selected for this comprehensive review because it contains an unusually detailed and up-to-date summary of the stratigraphy, facies analysis, and geologic history of the gigantic ancient reefs, worked out on the evidence of her own and her associate's studies of the outcropping reef massifs of the "Shikhany," and of the cores from the numerous bore holes; and also on her critical use of the previously published data and conclusions about these reefs.

The most essential parts of Rauser's essay are translated verbatim, and other parts are condensed and re-told. Explanations for some pertinent paleontological, stratigraphical, and facies terms and expressions are added by the reviewer, mostly on the basis of other Russian and non-Russian sources of information.

The most important of Rauser's illustrations (line drawings) are reproduced, with Russian geographic terms transliterated, and explanations translated.

Explanations for the five half-tone plates are translated, and an index of fossil references added; the index may be of some use to the Russian readers of this important essay. The condensed "historical review" serves as annotation to the appended bibliography.

Following is a guide to the review and additions to it from other sources on the region.

"Brief information on the relief of pre-Kungurian deposits" is a description of the structure drawn at the base of Kungurian deposits in lieu of the described structural map. Such a structural map for the Ishimbayev region called "Map of subsurface relief of Artinskian limestone massifs ..." is reproduced here, however, from Shamov's 1940 paper (his fig. 1 on p. 8). The "Geological section of eastern reef..." is a pictorially modified section (in Trofimuk and Dubrovin, 1936, fig. 2 and Shamov's fig. 2) along the N-O line shown

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in Shamov's map.

Rausser's chapter on the stratigraphy (her p.16-20) is translated verbatim. Her two chapters on facies (p.21-26) and facies analysis (p.26-31) are comprehensively reviewed and her definitions quoted. The chapter on facies in Ishimbaevo region (her p.31-34) is translated almost verbatim.

The very long chapter (p.35-70) on "Distribution of various facies in stratigraphic succession," contains very detailed information on lithology and distribution of fauna and flora for each of the twelve stratigraphic horizons differentiated. Only the most important parts of this chapter are reviewed and translated; but all twelve of Rausser's maps, which graphically show the distribution of the facies at each of these horizons are reproduced. In order to facilitate understanding of the shift of facies in the course of geologic time, the outlines of the reef massifs in each of Rausser's maps are here hatched out, and the maps are superposed in a natural succession from lowest to highest.

The chapter entitled "General remarks" (her p.79-84) is only briefly reviewed, with emphasis on its main data on the thicknesses of the major stratigraphic units. Three of the five maps are reproduced. The same outlines of the reef massifs shown in these maps are again hatched by the reviewer.

The chapter on paleogeography (p.84-100) is only briefly reviewed, with emphasis on the explanation of (Fig. 1, p.46) showing "Geologic and Paleogeographic" profiles in Tara-Tau area. But both paleogeographic maps (her Figs. 19 and 20) appended to this chapter by Rausser are here united in one figure to facilitate understanding of the paleogeographic change in the region, from late Schwagerina to early Sarga time. Rausser selected these two paleogeographic maps for publication because they are more complete for the region than the rest of the twelve maps composed by her, and because they "illustrate the most interesting moments" of the geologic history of the region.

The principal parts in the last chapter devoted to "Basic conclusions", are trans-

lated verbatim or nearly so, except that the conclusions 6 to 8 (last), where argumentative parts were, for the most part, repeating arguments in the text, were condensed.

The "Bibliography" contains many items added by the reviewer, mostly paleontological papers in which the fossils mentioned in the text are described and illustrated.

The "Index" compiled by the reviewer refers to the pages in the text of Rausser's paper, and to the pages of this review. The list of abbreviations of author's names of fossil species is also added by the reviewer.

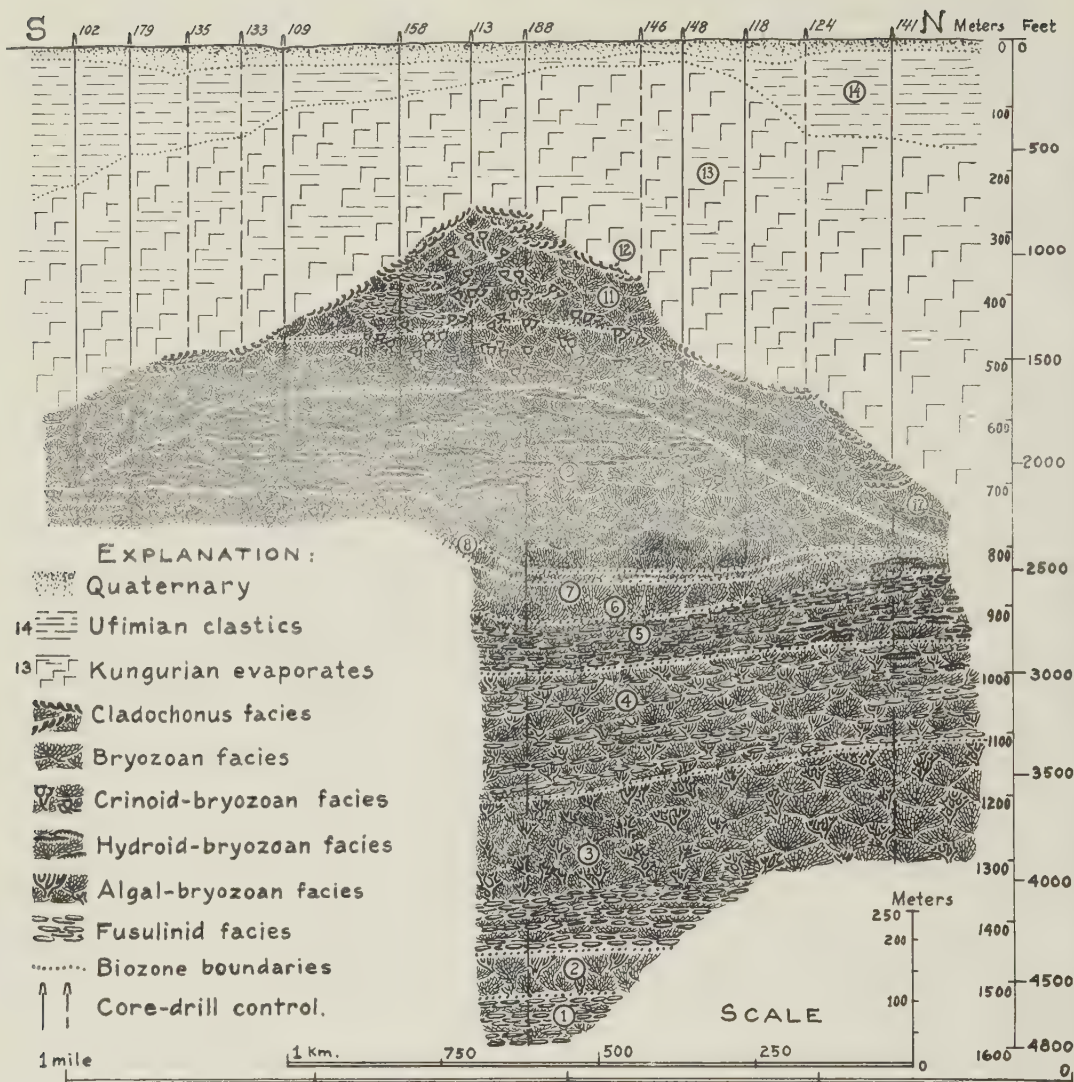
Two notes by the reviewer are added at the end for this purpose: to explain some peculiarities of the historically-molded, Russian stratigraphical differentiation and nomenclature; and to attach proper paleontological names to the reef-building fossils discussed and illustrated by Rausser-Chernousova, but without assigning generic and specific names, or giving only a new generic name without a specific one (Shamovella) and later properly introduced and described in detail by Maslov. The most important illustrations of these fossils supplied for the first time by Rausser-Chernousova are here reproduced, so that they could be compared with similar and different Carboniferous and Permian reef builders elsewhere in the world.

The numbers appearing in the left margins indicate corresponding pages in the Rausser-Chernousova paper.

Words in square brackets are added for sake of clarity; in some cases they are transliterated Russian words, when the translation is misleading.

### Historical Review

The geology of the vicinities of Sterlitamak and Ishimbaevo of the Bashkir region became known to geologists as a result of Murchison's 1845 description of the group of prominent isolated limestone mounds or "shikhany" (plural of shikhan, a native geographic term for these knolls or mounds), although the Russian geologist Kvalen (1843) described them before Murchison. Noschel (1853) published one



of the first geologic maps of the region; collections of its well-preserved late Paleozoic fossils were described by Kutorga, Keyserling, Moeller (1878, 1880), Tschernyshev (1902), and Karpinskii (1891), but the fossils described have not been precisely located.

Rausser groups these early investigations into what she calls the "prehistoric" period of the geologic investigations of the region, followed by a second period inaugurated by the remarkable investigations under the leadership of Noinsky in 1915-1916, and again in 1928-1930. In the third period, 1938 to 1942, during the second World War, investigations in the region practically ceased, but were resumed and carried on

intensely in the Fourth post-war period.

Among the most important results of Noinsky's contribution is the limitation of the Schwagerina horizon to the beds actually containing *Schwagerina princeps* in Moeller's sense, thus reducing the horizon to 6-7 meters thickness. Tscheruyshev's expanded concept of the Schwagerina horizon was based on a complex of brachiopods, by the use of which he attempted to classify as "Schwagerina horizon," some beds that carried no Schwagerina at all. The suite of limestones overlying the Schwagerina-bearing beds and containing corals, bryozoans, brachiopods, and ammonoids, were classified by Noinsky as post-Schwagerina Permian. He initiated a

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FIGURE 2. Geological section of eastern reef of Ishimbaevo oil-field, with pictorial indication of the reef-building organisms. (Modified from the section of Shamov, 1940, part of Fig. 2, and explanations published by Trofimuk and Dubrovin, 1936, Fig. 2, and Shamov, 1940, Fig. 2.)

The successive formations and faunal zones are as follows (as indicated by the numbers in the circles).

	Thickness in feet
15. Pleistocene deposits . . . . .	30 - 120
Upper Permian:	
14. Ufimian sands, marls, and clays. . . . .	50 - 750
13. Kungurian anhydrites, selenites, rock-salt, sands, and clays	600 - 1800
Lower Permian (Artinskian):	
12. Gray to black Cladonchous limestone . . . . .	to 270
10-11. Crinoid-bryozoan limestones and dolomites, characterized by <u>Pseudofusulina lutugina</u> above, and <u>Ps. concavatus</u> below . . . . .	to 900
9. Crinoid-bryozoan (below) to hydroid-bryozoidal (above) lime- stones to some dolomites, characterized by <u>Pseudofusulina</u> <u>urdalensis</u> . . . . .	to 900
6-8. Fusuline-crinoid-bryozoan limestones, to some dolomites below, characterized by <u>Pseudofusulina moelleri</u> . . . . .	to 420
Upper Carboniferous (American Wolfcampian):	
5. Bryozoan-fusulinid limestones to some dolomites, charac- terized by <u>Schwagerina sphaerica</u> . . . . .	120 - 270
4. Bryozoan-fusulinid-algal limestones to some dolomites, characterized by <u>Schwagerina constans</u> . . . . .	660 - 690
3. Bryozoan-algal limestones, characterized by <u>Schwagerina</u> <u>Robusta</u> var., and <u>S. fusiformis</u> var. . . . .	720 795
(Pseudofusulina horizon)	
2. Bryozoan-algal argillaceous limestone, with no fusulines; or limestones to dolomites, characterized by rare <u>Triticites</u> cf. <u>whitell</u> . . . . .	150 - 160
Triticites horizon	
1. Crinoid-bryozoan-fusulinid limestones and dolomites, characterized by <u>Triticites arcticus</u> , <u>T. whitell</u> and <u>T.</u> <u>acutus</u> . . . . .	180 - 215

NOTES: Schwagerinas of zones 3 to 5 were preliminarily identified as S. princeps. Most American paleontologists would classify them in genus Paraschwagerina; and would classify the listed species of Pseudofusulina in genus Schwagerina sensu Dunbar and Skinner. Horizon 9 with Pseudofusulina urdalensis was originally named by Rauser-Chernousova (1936) a horizon with Pseudofusulina anderssoni Schell. In a subsequent monographic work on the fusulinids of this same fusulinid was established as Pseudofusulina urdalensis Rauser (1940).

Following is the correspondence of the enumerated stratigraphic units to the units in the reviewed Rauser-Chernousova paper:

- |         |  |
|---------|--|
| 12.     | Sarga horizon ( $P_1^{III}$ )                      |
| 11.     | Irgina horizon ( $P_1^{IIb}$ )                     |
| 10.     | Burtsevo horizon ( $P_1^{Ib}$ )                    |
| 9.      | Sterlitamak horizon ( $P_1^I$ )                    |
| 6 to 8. | Tastuba horizon ( $C_3^{IV}$ )                     |
| 5.      | Upper zone of Schwagerina horizon ( $C_3^{IIIc}$ ) |
| 4.      | Middle zone of Schwagerina horizon ( $C_3^{IIb}$ ) |
| 3.      | Lower zone of Schwagerina horizon ( $C_3^{IIa}$ )  |
| 2.      | Pseudofusulina horizon ( $C_3^{II}$ )              |
| 1.      | Triticites suite ( $C_3^I$ )                       |

facies instead of stratigraphic significance for the Artinskian sandstones, by pointing out that they are near-shore facies of post-Schwagerina limestones; the lateral change from sandstones to limestones was observed by him in the Yurak-Tau shikhan.

His pupil and successor Gerasimov (1929-1937) has proved a repetition of Tschernyshev's "Cora horizon," (named after Productus (Linoproductus) cora, sensu lato): one below, and the other above the stratigraphically restricted

(by Noinisky) Schwagerina horizon.

Further investigations of the Shikhany (knolls) were carried out by Mikryukov (1937), Trofimuk (1936), Varov (1935) Bezrukov and Vorozheva (1937), and Trofimuk and Pakhomova (1938). Rauser-Chernousova (1937, 1940) and Shamov (1938) initiated the use of fusulinids for a detailed study of the geology of Shikhany. Particularly important is Shamov's conclusion about the westward shifting of the reef summits in the course of geologic time,

which may have led to the observed topographically lower position of some summits in subsequent time, for instance in Tastuba versus Schwagerina time. Shamov explains this phenomenon by a postulated continuous growth of Shikhany reefs in the course of an overall slow subsidence; at rare times of elevation, some widening of the reefs occurred, though not accompanied by upward growth. Rauser confirms these observations.

The Ishimbaevo region was a subject of important investigations by Blokhin (1932), who established the sub-meridional trend of the Ishimbaevo subsurface limestone massifs, analogous to that of the exposed massifs of the Shikhany. Osipov (1933) recognized the importance of tectonic processes in the genesis of the Ishimbaevo massifs, but suggested also that probably in some parts of the massifs, reef-building processes and pre-evaporite erosion molded their bizarre shape. He also noted an interesting parallel between the Ishimbaevo and Chusovskie Gorodki geology and tectonics. Bogdanov (1935) worked out an idea of the cupola-like nature of the Ishimbaevo folds, and suggested gradual evaporation in the local basin in late Artinskian time.

A systematic lithologic and paleontologic investigation of the Ishimbaevo cores were conducted by the following authors: on the fusulinids by Rauser-Chernousova (1935, 1937, 1940), Belyaev and Rauser-Chernousova (1938), Vissarionova (1937), Korzhenevsky (1940), and others; on bryozoans by Nikiforova (1939), Shulga-Nesterenko (1941), Novikova (1938) (and Trizna, 1939); on brachiopods by Kulikov (1938), Mikryukov (1937); and on ammonoids by Gerasimov (1937).

Rauser-Chernousova, Shamov, Vissarionova, and Korzhenevsky worked out detailed stratigraphy of the Ishimbaevo massifs on the evidence of fusulinids, and established the occurrence of transgressive overlap of the Cladochonus limestones over the sub-horizontal massif limestones. They substantiated the reef hypothesis of origin, rejecting the brachianticlinal hypothesis, and introduced some corrections to the stratigraphic schemes of Trofimuk and Dubrovin (1936), the staunch advocates of the reef origin of the Ishimbaevo massifs.

Similar views on reef origin were expressed by Sermiyagin (1939), Alexandrova (1939), and others. Sermiyagin cites V.N. Makhaev's (1940) identification of green, siphonaceous, and blue-green algae in the Ishimbaevo limestones. Postovskii and Getsen (1935) established the presence of porphyrins and products of decomposition of chlorophyll and hemin in the bitumens of the Ishimbaevo; and Radchenko (1938) verified it by spectral analysis. Her work resulted in finer discrimination between the bitumens coming from various horizons of the massifs, and she established a prevalence of humic over fat substances in Pseudofusulinid and Upper Artinskian horizons. She concluded that the composition of the humus indicates an influx of debris of higher land vegetation.

Facies analysis was applied in the study of the massif by Dubrovin, Trofimuk and Vissarionova, and Shamov. A. B. Pakhomova has supplied rich and well-illustrated geological material from the study of several horizons and has made valuable suggestions about the location of the apex of the Tara-Tau structure east of the Tara-Tau mound, and also about the presence of a reef in the western limb of the structure.

Dobrolyubova (1936) and Porfirev (1939) summarized stratigraphic and geographic distribution of the corals in the massifs. Vissarionova worked out *Stafella* and small foraminifera facies. Great attention to the study of facies of the massif was given by Shamov, but some factual stratigraphic and structural data revealed by I. S. Suleimanov resulted in some correction to his scheme.

Important summary and conclusions on the Shikhany and the buried massifs was published (posthumously) by Gubkin (1940), who emphasized the importance of the sharply-dissected relief of the Ishimbaevo massifs and their three-times repeated erosion, that reached down to the base of the Schwagerina horizon and resulted in differential highs up to 1000 meters in pre-Kungurian relief. Summarizing the known data, he postulated a series of faults, making an angular border along the eastern edge of the Ishimbaevo massifs, and in the north, bordering the Shikhany on the west. According to Gubkin the Cladochonus limestone has been laid down unconformably

during the subsidence of the massifs, which were previously elevated to a great height and eroded.

Teodorovich (1941) revived the problem of migration of the reefs, and Stepanov (1941) published a valuable summary on the Carboniferous and Artinskian of the Bashkiriya.

A large collective of the geologists, stratigraphers, and lithologists of the Academy of Sciences started work in 1941; and only that part of their work that is directly concerned with Rauser's facies analysis is incorporated in the reviewed essay. Particular attention has been paid by the collective to the problem of facies, paleogeography, and geologic history of the region. Special study of the Cladochonus limestone was made by Lipina (1949) who established its origin in shallow and fairly quiet waters. Soshkina (1945) proved the synchronicity of the Cladochonus and Upper Artinskian deposits, detailed out many other aspects of the stratigraphy and tectonics, and established their different characters in Ishimbaevo and Shikhany areas.

V. N. Krestovnikov has restored the paleogeography of the whole region on the evidence of the distribution of phosphatization, glauconite, and siliceous rocks. The genesis of the massifs and the paleogeography of the region were also the subject of works by Maslov and Belikov, Keller, Rauser-Chernousova, Khvorova and Soshkina, and others, and is reported on in published papers by Maslov (1943, 1945, 1946) and D. V. Nalivkin (1943).

"Though opinions on the origin of Ishimbaevo and Shikhany belts of massifs differ, there is no substantial divergence in the understanding of their geologic structure. A. A. Bogdanov's (1947) concept of the tectonics of the Ishimbaevo uplift is based on well-substantiated observations by Rauser-Chernousova and others. Only the nature of the steep flanks of the Ishimbaevo and Shikhany elevations still remains debatable. Some authors are inclined to regard them as flexures (Rauser-Chernousova, Keller, Bogdanov), while others allow for possible disjunctive dislocations (Teodorovich, Shatsky, and others).

The most intense discussions center on the degree of the intensity of erosion, and on the explanation of the geological sections east of the massifs. Some authors (Maslov, Belikov, Strakhov), who adhere to the views of Gerasimov and Stepanov, visualize the massifs as "erosional remnants cut out of a single, huge, layered reef body during pre-Upper Artinskian time. Others (Rauser-Chernousova, Keller, Khvorova, Soshkina, Krestovnikov) believe that the role of erosion in the shaping of the different parts of the massifs are different, because the deposits to the west and the east of the massifs are not identical. Khvorova (1947) expresses the extreme view on this matter, as she believes that the thin deposits to the east of the massifs, beginning with Schwagerina horizon, are of a bathyal origin, deposited at a depth of about 1000 meters. A different view is expressed by Korolyuk (1947), who endeavors to prove that the original absence of the deposits east of the massifs in late Schwagerina or Taštuba and up to early Artinskian time is a result of a [postulated] marine current.

A number of papers are devoted to the problems of facies and paleogeography of the Bashkirian ante-Urals (Teodorovich, 1942, 1948-A, 1948-B; D. V. Nalivkin, 1943; V. D. Nalivkin, 1944; Ruzhentsev, 1946, 1948). However, in their treatment of the more general problems of paleogeography and major facies of great territories, they have paid comparatively little attention to the Sterlitamak-Ishimbaevo region proper."

Brief Information on Relief of pre-Kungurian deposits. Written with Mrs. I. K. Korolyuk.

"The part of the Sterlitamak-Ishimbaevo region in the general tectonic scheme of the ante-Urals has already been discussed in papers by N. S. Shatsky, A. A. Bogdanov, and H. M. Strakhov. The relief of the pre-Kungurian rocks of this region has been also repeatedly described; but it seems desirable to outline it here for better understanding of the following text:

"Let us imagine that the great (200 to 1400 meters) thickness of the Kungurian and Ufimian rocks are removed. This will expose a very complex surface of pre-Kungurian limestone with several rows of

ranges and various depressions between them. The difference in absolute elevation of the highest and lowest points in this relief is 2000 meters. Shape, height, and interrelationships between the different morphologic elements of the relief change from east to west. The whole surface plunges from the Ural mountains westward to an average angle of  $4^{\circ}$  to  $7^{\circ}$ . Upon this slope rise a number of meridional ranges, the absolute heights of which diminish toward the west, but at a lower rate than the surface of their foundation; this results in a gradual increase in the relative height of these ranges above the sloping surface. Farther west, at the meridian of Pokrovka-Allaguvatovo this type of relief changes abruptly to a high, flat, and undissected elevation.

"The easternmost among the known ridges are the Pastushinskii-Karlinskii and Kinzebulatovskii Ranges. These two ranges are located on a single line, and in the large interval between them are possibly located unknown small ranges.

"The northernmost, Pastushinskii-Karlinskii Range, is made substantially of two small ranges in an offset position to each other, with a total meridional extension of 11-12 kilometers. Both ranges are narrow with flatten crests 2-2-1/2 kilometers in width, and steep (up to  $50^{\circ}$ ) slopes. Their estimated height is 500 meters, and the width at the base (at minus 800 meters elevation) is 4 kilometers.

"The Kinzebulatovskii Range extends meridionally for 9 kilometers and has a narrow flattened crest and steep slopes ( $40^{\circ}$ ). Its elevation is about 600 meters above the base.

"To the west of these ranges, in the north and south of the region, are located areas of deep and wide depressions. In the central part of the region there are no depressions at all, or if there are any, they would be insignificant in width. Directly adjacent to the mentioned[central] elevated zone is a large massif of the Shikhany uplift.

"The northern Dmitrovskaya Depression (not indicated on the maps) is bordered on the east by the Karlinskii Range, on the south by the Dmitrovskii elevation, in the

west by the Kuganaksii Massif, and in the north by the Pokrovskii Massif [not indicated on the maps].

15 "The Dmitrovskaya Depression sends it steep side tongues between the surrounding elevations. Its bottom, which is apparently flat, has an absolute height of minus 600 meters and in the southeast it runs into the Mrakovskaya Depression.

"The southern, Smakaevskaya Depression is located to the west of the Kinzebulatovskii Range. It has a flat bottom and steep ( $20^{\circ}$  to  $40^{\circ}$ ) and high (600-1000 meters) walls. In the south the depression runs into a large Allakaevskaya Depression (not indicated in the maps); in the north it is bordered by the Shikhany elevation. The tall Ishimbaevo Mountains, that are situated to the west of the Smakaevka Depression, are made of four separated Monadnocks: Yar-Bishkadakskii, South-Kashkarinskii, Kusiapkulovskii, and Ter-men-Elginskii massifs; and the irregularly shaped large range is divided into five massifs: Vestochnyi (eastern), Zapadnyi (western), Yuzhnyi (southern), Kuzminovskii, and Buranchinskii. The strike of the mountains is northwest in the south, and becomes meridional in the north. The height increases in a southerly direction from 700 to 1000 meters.

One of the Ishimbaevo monadnocks, the Kashkarinskii Massif, is located on the slope of the Allaguvatovsko-Pokrovskaya elevation. The Kusiapkulovskii Massif is separated from this elevation by a narrow depression, which widens to the south of Zapadnyi Massif, as it deepens and runs into the Buranchinskaya depression, with an absolute elevation at its bottom of minus 1200 meters. Farther south this depression runs into the Allakaevskaya Depression.

"Between the mentioned northern (Dmitrovskaya) and southern (Smakaevskaya) Depressions the Shikhany Range with its very uneven heights is located. This is an enormous mountain range, stretching for about 23 kilometers. Its average height gradually diminishes to zero in the vicinity of Orlovka in the south, and terminates much more abruptly just next to the Yurak-Tau in the north. The range reaches 900-1100 meters in its

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central part. Its western slope is very steep ( $40^{\circ} - 45^{\circ}$ ). The foot of the Shiknay Range in the west is at minus 900 meters elevation, and the range is bordered here by a narrow depression.

"The crest of the range is much dissected, with greatest heights at Tara-Tau, Shak-Tau, Kush-Tau, and Yurak-Tau, their relative heights above the general Shikhany elevation ranging from 300-400 meters. Malyi and Novyi Shikhany have a lesser height. The base of the Shikhany elevation is wide and slopes gently toward the east. The summits of the four principal shikhany mounds rise about 200 meters above the present surface of the Kungurian and Ufimian rocks [which is practically the surface of the local plain], and are well known in the literature as the Sterlitamak monadnocks (gory-odinochki). Directly to the north of them and on the same meridional line are located several minor solitary elevations: Severnaya Pokrovskaya, Kuganaskaya, and Dmitrovskaya. Their absolute height is minus 200 to minus 300 meters, and the elevation over the surrounding depressions is from 300 to 400 meters. The area of each of these mounds is very small, 2 to 3 square kilometers, and their slopes gentle, up to an angle of  $5^{\circ} - 8^{\circ}$ . To the east of them is the previously mentioned Dmitrovskaya Depression; and at their western foot starts the gentle slope of the western table land.

"Thus the relief of the pre-Kungurian rocks is quite complex, with abrupt changes in the east-west direction. In the east are steep and narrow ranges, while in the west the elevations are larger and of irregular shape. This peculiarity reflects the tectonic difference: the eastern ranges are steep linear folds, while the western uplifts are larger and more complex asymmetrical anticlines.

### <sup>16</sup> Stratigraphy of the Upper Carboniferous and Artinskian rocks.

#### Upper Carboniferous

The following deposits are referred here to the Upper Carboniferous (from bottom up): *Triticites* suite, and the *Pseudofusulina*, *Schwagerina*, and *Tastuba* horizons.

*Triticites* suite ( $C_3^I$ ). The *Triticites* suite is represented by light colored massif limestones or by gray, stratified limestones, occasionally with inlayers of dolomite or of clayey and bituminous shale. The thickness ranges from 60 to 150 meters.

*Spiroplectammina bashkirica* Raus. is characteristic for the entire suite, which may be divided into three zones on the evidence of the fusulinids (from bottom up):

1. Zone with *Triticites montiparus*, which in turn may be further subdivided into a lower sub-zone with *Fusiella lancetiformis* Putrja, *Protriticites*, and occurrence of fusulinellids (*Fusulinella pulchra* Raus. et Bel., *Fusvae* Dutk., and others); and upper sub-zone with *Triticites shikhanensis* Ros.

2. Zone with *Triticites arcticus* and *T. acutus*, and in which are also encountered *T. Paraarcticus* Raus. *I. simplex* (Schellw.), and others.

3. Zone with diminutive triticites: *Triticites parvulus* (Schellw.), *T. primitivus* Raus., *T. karlensis* Ros., and others.

The first two zones correspond to the same zones differentiated in the Russian Platform; but the zone with the diminutive triticites is local, and seems to be synchronous with the two upper zones of the *Triticites* horizon of the Russian Platform.

*Pseudofusulina* horizon ( $C_3^{II}$ ). The *Pseudofusulina* horizon is usually expressed by clayey-carbonate deposits, which are frequently silicified and rich with glauconite; inlayers of bituminous argillites are encountered, and occasionally also phosphatic concretions. Less frequently the horizon is represented by light-colored, massif biomorphic limestones. The thickness ranges from 20 to 50 meters.

The following organic remains are characteristic: vegetative detritus, sponge spicules, remains of fishes, *Spiroplectammina bashkirica* Raus., ammonites, earliest pseudofusulines of the groups of *Pseudofusulina krotowi* (Schellw.), and *P. paragregaria* Raus., and others.

*Schwagerina* horizon ( $C_3^{III}$ ). The *Schwagerina*

rina horizon may be divided into three zones on the evidence of the fusulines. Other fossils help to differentiate only the middle and upper zones:

- 17 Lower zone of Schwagerina horizon ( $C_3^{IIa}$ ). The lower zone consists of light gray and gray organic-detrital and biomorphic limestones with inlayers of dolomites.

Thicknesses are 230 to 240 meters in the Ishimbaevo massifs and 80 to 150 meters in the Tara-Tau area.

Organic remains consist of bryozoans, foraminifers, corals, and brachiopods. Characteristic among the foraminifers are Bradyina compressa var. minima Mors., and groups of Pseudofusulina paragregaria Raus. and P. krotowi (Schellw.). Most characteristic are schwagerines of Schwagerina vulgaris and S. fusiformis Krot. groups.

Middle zone of Schwagerina horizon ( $C_3^{IIb}$ ). In the southern elevations the middle zone consists of massif limestones interbedded with dolomites. In the northern elevations it consists of bluish-gray aphanitic, finely-detrital and biomorphic limestones, interchanging with dolomites. In the deeper parts of the basin it consists of the thin clayey limestones and marls.

Thicknesses are 215 to 300 meters in the southern elevations, 40 to 50 meters in the north, and 15-25 meters when in clayey-carbonate facies.

Organic remains are rich and varied. Very widespread are algae: Shamovella (= Tubiphytes Maslov), mizzias siphonaceous, and blue-green; also foraminifera and bryozoans. Hydractinoids make their first appearance in this zone. Most characteristic among the foraminifera are thick-shelled climacamins of group Climacammina gigas Sul., with most characteristic C. gigas var. major Mors., frequent nodosarias (Nodosaria elegantissima Sul. and others); earliest glomospires; Schwagerina constans Scherb.; Pseudofusulina rhomboides Sham. et. Scherb., P. fecunda Sham. et Scherb., and species of P. krotowi and P. paragregaria groups. There is a characteristic datum bed with mass occurrence of P. paragregaria var. ascendens Raus at the roof of the zone. (The next

line in Rauser's text reads "All species of pseudoschwagerines are characteristic" may be a typographical or manuscript error, because no species of the genus Pseudoschwagerina are mentioned here or elsewhere in her text; and in her understanding Pseudoschwagerina is a junior synonym of Schwagerina sensu Moeller.) Among the bryozoans Fenestella biarmica var. perinsignis Nova and F. crassiseptata Sch.-Nest are possibly characteristic. Upper zone of Schwagerina horizon ( $C_3^{IIc}$ ). The upper zone consists of gray detrital, biomorphic and biohermic limestones with inlayers of dolomites, which are developed all along the Ishimbaevo and Shikhany elevations. In the north predominate bluish-gray, compact dolomitic limestones with inlayers of marls and dolomites. In the deeper parts of the basin the zone is represented by the thin clayey-carbonate sediments.

Thicknesses are 60 to 100 meters in the south, 25 to 60 meters in the north. The clayey-carbonate facies is 12 to 25 meters thick.

Bryozoans, hydractinoids, corals, and shamovells (= Tubiphytes Maslov) are encountered in the bioherms. Characteristic among the small foraminifera are Glomospira regularis Lip., Agathammina compressa Lip., Nodosaria longa Lip., and among the fusulinids the species of Pseudofusulina uralica (Krot.) group and Schwagerina sphaerica Scherb. Characteristic is the appearance of large forms of Pseudofusulina sulcata group and frequent rugosofusulines. Among the characteristic corals is the first appearance of prismatic forms (Thysanophyllum cystosum Dobr. and Tschussoskenia captiosa Dobr.; the latter is perhaps restricted to Schwagerina horizon). Among the characteristic bryozoans are Septopora ovalis Nov. and Fenestella rhomboides var. juncta Nov., also F. cyclotriangulata Sch.-Nest., and others.

Tastubskii (Tastuba) horizon ( $C_3^{IV}$ ). Tastubskii horizon may be differentiated into three biozones, each consisting, in turn, of three facies. This divisibility of the horizon and the differentiation in it of datum beds have played a decisive role in clarifying the geologic structure of the massifs.

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The sediments of the Tastuba horizon are much diversified lithologically and paleontologically, with extraordinarily variable facies; and yet the general type of the rocks is maintained all over the horizon and over the area. In the elevated reef massifs the horizon is represented by limestones, which are usually gray and detrital, less frequently biomorphic and biohermic, or by detrital rocks, composed of calcareous sand and gravellites, with inlayers of dolomite. In the elevations of Karlinskii type are developed bluish-gray limestones, dolomites, and marls, not infrequently with bluish chert. In the deep parts of the basin the horizon is represented by the detrital shaley limestones, dolomites, and marls.

Thicknesses range from 100 to 250 meters in the massifs, 15 to 35 meters in the elevations of Karlinskii type and 20 to 30 meters in the clayey-carbonate facies.

In the lower part of the horizon the organic remains are much diversified, but in the upper part they are notably impoverished. Among the rocks of biomorphic and biohermic nature the bryozoan, coral, and bryozoan-brachiopod-stromatolitic limestones are predominant. Occasionally hydractinoid and mizzia (siphonaceous algae) limestones occur.

Geinitzia magna Lip., Tetrataxis lata Spand., T. irregularis Mors., and other small foraminifer are characteristic for the whole horizon.

Among the brachiopods of the lower zone, the most characteristic is the complex of the so-called Schwagerina type<sup>1</sup>; while some brachiopods in the upper two zones continue on into the overlying horizon. Corals are represented by a much diversified complex of prismatic forms, and it is possible that the genus Diphytrotion is restricted to her horizon. Bryozoans are particularly numerous in the two lower zones, and are sharply different from those in the Schwagerina horizon. Characteristic among them are Polypora ornamentata Sch.-Nest., and Septopora subinvisa Sch.-Nest. In the upper zone the number of spe-

cies and genera is much reduced; characteristic for this zone is Archimedes curtus Sch.-Nest.

The fusulinids provided the best means for the differentiation of the horizon into three zones.

The lower zone is characterized by the joint presence of rugosofusulines with the newly appearing species of Pseudofusulina moelleri group.

The middle zone is characterized by the absence of rugosofusulines, while the Pseudofusulina moelleri group continues its development, P. moelleri var. aequalis (Schellw.) and P. devesa Raus. with its varieties being dominant. Characteristic for the zone is also Pseudofusulina uralica (Krot.) P. electa Sham. group.

The upper zone is characterized by three new groups of Pseudofusulina verneulli, of P. confusa, and of P. urdalensis, the developments of which continues from her on upwards, into the Sterlitamak horizon of the Artinskian stage. This fact and the previous noted similarity of the brachiopod faunas in the upper Tastuba and the 19 Sterlitamak horizon, and also an abrupt change and impoverishment of bryozoans in the upper zone of the Tastuba horizon, all point to the possibility of location of the lower boundary of the Permian not at the top of the Tastuba horizon, but at its bottom.

Most characteristic for the horizon among the fusulinids are Pseudofusulina verneulli and P. confusa.

Lower Permian  
(Artinskian stage)

Artinskian stage is divided into four horizons: Sterlitamaskii (Sterlitamak), Burtsevskii (Burtsevo), Irginskii (Irgina), and Sarginskii (Sarga). The first three belong to the lower sub-stage, and the Sarginskii to the upper sub-stage of the Artinskian.

Sterlitamaskii horizon ( $P_1^I$ ). The variability of the facies in the deposits of the Sterlitamaskii horizon is even greater than in the Tastuba horizon, a result of still more intense diversification of the submarine relief during Sterlitamak time. Only in a few places (in the massifs de-

<sup>1</sup>Apparently in the sense introduced by Theo. Tschernyshev (Reviewer).

veloped at that time) are seen preserved the biohermic light-gray massif limestone layers up to 300 meters thick built by the bryozoans and hydractinoids; there are also a few thin coral banks. Predominant are the detrital limestones with inlayers of dolomites. Layers of marls and of bluish chert are developed in the limestones and dolomites in the elevations of Karlinskii type. In the deeper part of the basin have been deposited dark thin-layered dolomitized calcareous argillites and dolomites with inlayers of limestones and marls.

Thicknesses are: 100 to 200 meters in reef facies and are reduced to 60 meters in detrital deposits, about 35 meters in the elevations of Karlinskii type and 10 to 70 meters in clayey-carbonate facies.

Organic remains are fairly abundant but not diversified. Most numerous are the bryozoans and hydractinoids; less numerous are brachiopods, corals, foraminifers, and algae. Among small foraminifers, the most characteristic are Bradyina major Mors., and Endothyra lipinae Mors. Characteristic also is the mass occurrence of Pseudofusulina urdaensis Raus., P. plicatissima Raus., and others. In the lower part of the horizon, the occurrence of P. callosa Raus. and P. verneuilli groups is most common.

Polypora orientalis var. fenestelloides Trizna and others are characteristic for the whole horizon, while P. orientalis Eichw. is characteristic for the lower part and P. repens Trizna for the upper part.

Burtsevskii (Burtsevo) horizon ( $P_1^{IIa}$ ). The Burtsevskii horizon is represented in the massifs by the non-stratified limestones with inlayers of dolomites and in their lower parts some thick bryozoan and brachiopod-bryozoan bioherms are still encountered. Among the stratified limestones varieties (sometimes silicified or clayey) with fusulinids, brachiopods, and sponge spicules predominate. In the deeper parts of the basin, thinly stratified dolomites and marls with inlayers of argillites, containing sponge spicules, pyrite, and carbonized plant remains are developed.

Thicknesses are: 60 to 110 meters for non-stratified limestones, 50-60 meters

for stratified limestones, and 10-50 meters for microstratified rocks.

The fauna is much impoverished. Characteristic among the foraminifera are Bradyina lucida Mors., Pseudofusulina concavatus Viss., P. vissarionovae Raus., P. schellwieni Viss., and others. The bryozoans are much diversified, Fenestella retiformis var. lunaris Sch.-Nest., being characteristic. There is a complete renovation of the whole brachiopod complex, with an appearance of new forms similar to those occurring in the higher horizons.

Irginskii (Irgina) horizon ( $P_1^{IIb}$ ). The deposits of the Irginskii horizon are similar to those of the Burtsevskii horizon, but are distinguished by becoming more clayey, assuming darker color, greater silicification, and still greater paucity of organic remains. In the massifs some thin bryozoan and algal-bryozoan bioherms are developed. In the deeper parts of the basin are observed some dark microstratified dolomites and marls with inlayers of detrital shaley limestones, with the same kinds of organic remains as in the Burtsevskii horizon, but with a more frequent phosphatization.

Thicknesses are 150 to 175 meters for carbonate rocks and 10 to 25 meters for shaley-carbonate rocks.

The fauna is very poor. Characteristic among the foraminifers are Nodosaria parva Lip., Pseudofusulina lutugini (Schellw.), P. concessa Viss., and others. Characteristic are also Fenestella spinulosa var. permica Sch.-Nest. among the bryozoans, and Productus stuckenbergi Krot. among the brachiopods.

Sarginskii (Sarga) horizon ( $P_1^{III}$ ). The following basic types may be segregated from the extraordinarily diversified deposits of the Sarginskii horizon:

1. Cladochonus limestones, dark and shaley, with solitary ring-like corals, blue-green algae, foraminifers of glomospira, tolypammina, and "nubecularia" types. The thickness is usually 10 to 15 meters.
2. Biomorphic gray foraminiferal-algal

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limestones and cavernous dolomites, predominant are "nubecularias: among the foraminifera, and solenopores (?) among the algae. The thickness is from 80 to 100 meters.

3. Stratified dolomitized clayey limestones with bryozoans, sponges, fusulinids, and crinoids. The thickness is up to 100 meters.

4. Clastic limestones in the form of calcareous breccias and inlayers of calcareous breccias within the finely-detrital limestones and dolomites, or platy marls and argillites. Thickness is from 15-40 meters.

5. Dark thinly-stratified marls with ammonoids and phosphatized organic remains. The thickness is very small.

The fauna of the horizon is poor. Characteristic among the foraminifera are *Nodosaria mirabilis* Lip., *Pacyploia densa* Lip., *Parafusulina solidissima* Raus., *Pseudofusulina makarovi* Raus., and others, among the corals: *Cladochonus michelini*, *C. bolchovitinovae* Gors. *Hexagonella ishimbajica* Nik, and *Polypora biarmica* keys are also considered characteristic for the horizon among the bryozoans, and *Productus*<sup>2</sup> *aagaridi* Toulou among the brachiopods.

### Facies of the Upper Carboniferous and Artinskian Deposits

In a chapter on "Definition of concept of facies" (p.21-26) Rauser critically reviews the history of the concept since its inception by Gressly. She points out that the term facies has been applied increasingly to the events of the present and quotes Nalivkin (1931), who, she says, considers the contemporary "facies" a geographic sector of earth's surface, and the geologic "facies" a layer with specific qualities. But in Rauser's opinion, this transfer of the term "facies" to contemporary events "brings confusion" and should not be practiced. The term "facies" is essentially "dynamic," because the element of geologic time is its essential part. The study of facies (or Facieology, as the

reviewer suggests) has the same relation to paleogeography as ecology to geography. Ecology is a study of conditions of life, dynamics of environments and their inhabitants; its basic space unit is the ecologic niche, which may be smaller or larger than the lowest unit of biogeography (biotope)... She agrees with Nalivkin that "facies are bricks which build paleogeography," but insists that "facies is not an element of paleogeographic landscape, ... nor a rock," but is essentially "an abstract concept, an analysis of dynamics of changing conditions of certain medium in time and space; of condition of life and of sedimentation in the course of a sector of geologic time. It may be larger or smaller than a paleogeographic unit (belt or zone), and, besides, it is looked at from a different point of view. Facies is basically a combination of paleoecologic and sedimentary concepts."

In her final version of what is "facies" she writes "Facies is a combination of local petrographic and paleontologic peculiarities of a suite of uniform deposits, which indicate the physiogeographic conditions of their origin" (Rauser's italics, p.24,25).

Rauser selects Wells' term 'lithotope' for a higher category in facies analysis, "a combination of qualities of a group of genetically similar layers [of rocks], an integration of their conditions of deposition, that expresses the paleogeographic situation during their origin." She feels that lithotope is a "most suitable term, mentioning Wells' (1947) and Moore's (1948) use of it."<sup>3</sup>

"Rauser chooses the term 'lithotope' for an intermediate category (between

<sup>3</sup> Moore rejected "lithotope" in favor of "lithofacies," when publishing his final version of the 1948 presentation. Says Moore (1949), p.16 "The preliminary draft of this paper, which was prepared under somewhat arduous condition of European travel, and the oral presentation of the paper at New York in November 1948 employed the term 'lithotope' introduced by Wells, 1947, p.119, instead of lithofacies, (reviewer's italics). Whereas 'lithofacies' signifies the record of a sedimentary environment as represented by the sum total of lithologic characteristics of sedimentary rock, the term 'lithotope' (Wells, 1947, p.119) refers to the environment" (Footnote 3 continued at bottom of next page)

<sup>2</sup> *Linoproductus*, where *Productus* is understood in a restricted sense.

facies and formation)... because of its brevity, clearness of meaning (combination of sedimentation and space), and consonance with the analogous biogeographic concept, 'biotope,' which denotes a small unit of biotic space" (p.24).

Much care is devoted by Rauser to definition of the highest category in facies analysis, the "formation." "In formation the peculiarities of the lithotope assume still greater integration, and the lithologic and paleontologic characters yield place to paleogeographic ones. The fundamental feature of a formation becomes the inter-relationship between the sedimentary characteristics and geotectonic events; also fundamental is a regular combination of definite complexes of genetically related sediments. The concept of formation is primarily tectonic. It is represented by geologic suites. Distribution of a formation is wide, embracing tectonic regions. Stratigraphically, it may cross the boundaries of stages, divisions, (otdely), and (geologic) systems, or may coincide with them. In zoogeography, formation would correspond to geographic provinces, climatic belts, or, occasionally, (climatic) zones." (p.26).<sup>4</sup>

(Footnote 3 continued from preceding page).  
ronment itself, not the record of it. Similarly, the total biological characteristics of a sedimentary deposit, which are indicated by the term 'biofacies,' have a matching ecological term, 'biotope,' which signifies organic environment."

Because Rauser emphasizes the "abstract" nature of the term "facies," her selection of Wells' term "lithotope" is logical. On the other hand, in her own definition of the terms "facies" and "lithotope" she unifies the abstract concept of visualized conditions of the past with the peculiarities or characters actually observed in an analyzed rock. Thus, in the light of her definitions, the terms "lithotope" and "lithofacies" would be synonymous.

<sup>4</sup> The term "formation" thus defined stands in obvious conflict with the term formation as firmly established in the practice of American stratigraphy. This, in fact, is the only term previously widely used in geology and borrowed by Nalivkin in 1931, and now used by Rauser for facieological concepts. Hence, it would seem proper to coin a new term for this concept, for instance: formatiopon (new term).

## 26 Methods and Basic Principles of Facies Analysis

"...Two principle types of calcareous rocks have been differentiated: biohermic and detrital. Lithologists V.P. Maslov and B.P. Belikov have reached the following conclusions:

"(1) Biohermic type of limestones with organisms in life position constitute a substantial part of the rocks of Ishimbaevo massifs, but have a lesser distribution in comparison with detrital rocks.

"(2) Distribution of biohermic rocks is very irregular in the body of the massifs: they form generally only small-thickness bioherms, which grade at both flanks into very thick detrital trails (without obvious lagoon facies), and are covered up by suites of detrital rocks.

"(3) No regularity is observed in migration of bioherms within massifs.

"The data obtained by these lithologic investigations were augmented by the author in the course of stratigraphic investigation of the region. The biohermic rocks have been megascopically studied in about 30 geologic sections in order to establish genetically fundamental types of rocks, and for ecologic observation of the organisms buried in them. Ecologic study of biocoenoses and thanatocoenoses has been substantially augmented and widened by the observation of these same facies in shikhany, where good exposures occur.

"The basic material for the study of the lithology of the sediments was furnished by the study of thin sections containing fusulines. In all studied slides the following structural, textural, and mineralogical peculiarities were recorded: compactions and nodular aggregates, encrusting structures, spotty texture, presence of characteristic minerals (glauconite, pyrite, and others); and also of all organic remains. Among the latter the following were recorded: various algae, with special attention to mizzias, smaller foraminifera with generic (and rarely specific) identifications, specifically identified fusulinids, sponge spicules, hydractinoids (illustrated but undescribed), coral tissues, remains of echinoids (crinoidal columnals, spines of

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sea-urchins, anchors of holothurians), bryozoans, brachiopods, and ostracodes (observations on ostracodes included size, thickness of valves, and conditions of burial, that is, whether the valves are closed or separated)."

The data obtained by the author in the study of the fusuline-bearing slides have been integrated with the data obtained by V.P. Maslov and B.P. Belikov in their lithologic studies.

Altogether 226 columnar sections, mostly based on core-drilled holes, have been studied in some detail. The results of the study are represented graphically in twelve ecological maps showing the distribution of facies in twelve successive horizontal levels (Figs. 2, 3a, 3b, 4, 5b, 6, 7a, 7b, 8, 9, and 10; Figs. 8, 9 and 10 worked out by G.D. Kireeva). The division into 12 biostratigraphic zones are accomplished on the evidence of mass studies of fusulines.

28 "Following are some of the basic postulates in the facies analysis:

(1) The study of the Shak-Tau biohermic rocks has shown that in their midst are regularly distributed organic-detrital deposits which are the products of disintegration of the organisms at the place of their life.... This detritus fills all the voids of the reef construction (postroika), ... under the force of gravity, and without noticeable transportation by water currents. Because of this the detrital material assumed no stratification and no granular sorting. In the excellent exposures of the massif hydractinoid limestones of Shak-Tau can be seen how the hydractinoid cups and spaces between them have been filled up by a quite unsorted crinoidal organic-detrital material with fusulines in inclined orientation. The prevailing orientation of the latter is close to vertical, which indicates that they sank into semi-liquid ooze with sharp ends down.

The presence within the bioherm of detritus marked by such regularities allows the conclusion that this part of the non-stratified organic-detrital limestones is an integral part of the bioherm itself.

29 (2) The second characteristic feature of the biohermic rocks is the frequent

occurrence of breccias in the vicinity of bioherms. Apparently submarine creeps and slides of semi-liquid ooze down the slopes occurred in the area of reef constructions, especially at Shak-Tau.

(3) Zonal distribution of the facies shown in the maps has disclosed a regular succession from the shallower facies of the axial part of the massifs to the deeper facies of the marginal parts, and the corresponding sequence of zones of habitat of the various reef-builders. The sequence of the biostratigraphic zones has shown an identical change of facies in vertical direction. Obviously the latter has been induced by the oscillations of the sea level and by facies migration in space. The established uniform repetition of the facies sequences in horizontal and vertical directions provided convincing evidence of the understanding of the bathymetric disposition of the members of this facies sequence, and of the principal reef-builders that characterize them.

Thus, the shallowest-dwelling organisms in the Ishimbaevo region are hydractinoids, followed by bryozoans, then by corals, and finally by porcelain-like algae--shamovells (= *Tubiphytes*). The depth of these reef-builders probably varied within a 20-60 meter limit.

(4) Hydractinoid and bryozoan-built bioherms seemingly do not exceed a few tens of meters in thickness. The depth of habitat may be estimated at 20 to 40 meters. It may be supposed that the corals have formed banks (and not true reefs) probably of smaller thickness, not greater than 5-10 meters. Because of the easy crushing of the fragile and porous coral limestones, corals are almost unknown in the Ishimbaevo massifs, although coral detritus is quite abundant in thin sections, especially in the middle Tastuba deposits. In the excellent exposures of shikhany, the coral banks are beautifully developed. The corals seemingly populated bottoms which did not exceed 30 to 40 meters in depth. Shamovells (= *Tubiphytes*) hardly formed any true bioherms. Their skeletons are much too fragile and comparatively small for making thick reef construction through their own efforts. When they are the dominant component of a rock, they characterize biomorphic deposits of shallow

waters... In the Schwagerina horizon there are some pure stands of these algal tubules in the form of isolated biostromes with excellent encrusting structure, such as can be observed in the middle zone of the Schwagerina horizon of Shak-Tau, and in some thin sections from the Ishimbaevo massif. On the basis of this evidence they may be considered reef-builders, but their normal place is largely in biostromes and banks...

(5) Among the fusulines... occurring in the reef facies and localized shallows, there are largely forms that are much inflated, short, having narrow apertures, and possessing a reinforced endoskeleton characterized by intense fluting of septa and additional deposits. These characters undoubtedly reflect the reaction of the organisms to the strong agitation of water in shallow bottoms. Direct action of this force is evidenced by an extraordinarily large number of broken and subsequently healed individuals among the fusulines in the reef facies. This phenomenon is particularly characteristic for the reef facies; in other facies it is observed very rarely.

In the synchronous extra-reef facies represented by various organic-detrital limestones the same groups of fusulines are encountered. Other representative forms, characterized by a longer and subcylindrical shell and less frequent occurrence of reinforcements in the endoskeleton are dominant, however. Apparently the subcylindrical fusulinids were adapted to life in a comparatively open sea and quiet bottoms.

(6) Smaller foraminifera, according to Lipina's investigations, are impoverished in the areas of bioherms and shallow waters, and are distinguished by greater richness when in comparatively deeper marine deposits. The presence of small forms of the Ammodiscus and Nodosaria groups has been established in the fine-grained sediments not only outside of reefs but also in the reefs, seemingly in the most sheltered small depressions and niches. Besides, it may be supposed that Endothyra Bradyina, and Globivalvulina (and possibly also Tolypammina) lived in regions of lower temperature, slowed-up accumulation of sediments, and strong currents. It is

possible that this peculiar distribution of the mutually exclusive groups (of foraminifers) (the first principally in the southern massifs, and the second in the north) is due to the distribution of currents, that is warmer in the south, and colder in the north.

(7) ...the bryozoans of the bryozoan (and partly of the hydractinoid) bioherms are distinguished by their extraordinary variability, sharply intensified speciation, and very short range of existence.

(8) One of the difficulties in facies analysis is separation of biocoenosis from thanatocoenosis in the organic remains of a rock. There is no doubt that in the reef facies we deal largely with thanatocoenosis which is nearly identical with biocoenosis. The reef-builders, various algae, small foraminifera, and fusulines--the basic components of this facies--lived together in the place of their burial... It is not accidental that in this same facies thick-valved ostracodes with closed valves (that undoubtedly belong to this association) are also observed.

In the extra-reef facies thanatocoenosis in many cases is not the same as biocoenosis, various geologic factors contributing to its origin. Thus, in the facies of gentle slopes of the reef shallows smaller foraminifera, fusulines, and crinoids obviously are the biocoenosis of the sea bottom, while the bryozoan detritus has been transported to this region by water currents from the shallower region above... The crinoids and bryozoans have not lived together.

#### <sup>31</sup> Types of Facies in Ishimbaevo Region

Reef facies. There are two types of reefs and correspondingly two reef sub-facies: hydractinoid and bryozoan. Both are represented by not very thick ephemeral constructions that have not created a definite reef topography as is commonly understood. The principal distinction of the Ishimbaevo reefs is their continued complete submergence. Because of this they lack the usual reef differentiation into reef proper, lagoons, etc. Lithologic characteristics are: absence of stratification, spotty texture as a result of an uneven distribution of the reef construction and the detritus, encrusta-

tional structure in the primary voids within the reef along the pores and caverns, which were formed during crystallization and leaching out of the cement and of organic remains.

Besides the reef-builders (hydractinoids and bryozoans) the following rich and diversified organic life is present: diversified adnate and encrusting algae, very rich and peculiar complexes of bryozoans, thick-valved large ostracodes, gastropods, small brachiopods with well developed sculpture, inflated fusulines with reinforced skeleton and intense fluting of septa, and a comparatively poor complex of smaller foraminifera.

The thickness of this facies usually exceeds that of other facies. The areas of its principal distribution are limited, and concentrate chiefly along the fringes of the submarine plateau that faces the open sea (the eastern and southern fringes of the massifs during Schwagerina and *Tastuba* times), and besides, along the northern fringes of the large Buramchinsky bay during *Sterlitamak* time.

Facies of Ishimbaevo Submarine Plateau. The submarine plateau (with the exception of its fringes, where reefs predominate) has been a seat of a facies of shallow water banks. This facies is subdivided into two sub-facies: (a) *mizzia* (dasyclads) - bryozoan submarine banks with depths less than 40-50 meters (120-150 feet), and (b) algal submarine banks deeper than 40-50 meters (120-150 feet).

The first subfacies is usually encountered in the lithotopes formed by the interstratified organic-detrital limestones of very diversified kinds with thick biostromes: hydractinoid, *mizzia* (siphonaceous algae) and bryozoans, and corals. Small foraminifera are fairly diversified, and fusulinids are frequent, being represented largely by elongate forms; bryozoans are moderately distributed; crinoids are not infrequent. These subfacies usually coexist with reef facies, and manifest the periods of greater differentiation of [life in] the submarine plateau, stimulated perhaps by the warm currents running along its fringes.

The second subfacies, at depths greater

than 40-50 meters, typifies quieter and more uniform conditions of sedimentation and of life. Possibly there were some periodic fluctuations toward colder temperature, which are indicated by several layers with gregarious *Glomospira*. Sediments are usually biomorphic, complete skeleton prevailing over detritus. Spotty, reef, and encrusting structures are not infrequent. Limestones are distinguished by their massif character, absence of stratification and sorting of grain, and by purity and considerable thickness. Reef-forming hydractinoids, bryozoans, and corals are very rare, but the algae have flourished, the white tubules of *shamovella* (= *Tubiphytes*) occasionally encrust a rock known as wormy (*cherviachnyi*) limestone, or even forming lenses with sod-like constructions and showing beautiful encrusting structure. Besides the extremely diversified calcareous algae, this facies not infrequently contains small foraminifera, with prevailing *Glomospira*, *Tolipammina*, small *Ammodiscus*, and *Nodosaria*. Fusulines are poorly represented, and are quite absent in the beds rich with *shamovells* (= *Tubiphytes*). But in the neighboring layers, with richer detritus, fusulines are richly represented, mostly by inflated to spherical forms (in the middle zone of the *Schwagerina* horizon), and among the small foraminifera are found the large, also inflated thick-walled forms of *Climacamina*. The presence of such thick-shelled, shortened forms may be an indicator of conditions approaching those in reefs.

Characteristic of this subfacies is its widespread distribution, and building of expansive submarine banks with fairly uniform and stabilized lithologic and paleontologic characters.

Facies of Shallow Banks. To this facies belong the sectors of the reefs and submarine banks that are shallower, thus suffering noticeable influence of strong movements of water. Typical sediments of this facies are calcareous sands composed of well-rounded particles of organic nature (not infrequently hydractinoid sand), which are conspicuous by the light color of their particles. Their susceptibility to quick recrystallization resulted in small cavities (Pl. V, fig. 1). Fine gravels, composed of pebbles of either organic re-

mains (frequently of fusulines rounded into flat or round pebbles), or made of ooze with organic remains embedded in it. Coprolite-nodular ooze is very common in this facies (Pl. V, figs. 2 and 3). Characteristic for this ooze are two elements: (1) well delineated oval to sub-spherical coprolites about 0.5 to 1 mm. in diameter, made of dark fine-grained matrix mixed with fine organic particles, and (2) nodules of blue-green algae, which have a similar fine-grained structure, but whose contours are less sharply defined. In the coprolite-nodular oozes are encountered Glomospira, Tolypammina, Ammodiscus, and Hemidiscus and various encrusting and adnate blue-green algae, whose entangled thin filaments preserve their form well. Fusulines are also characteristic for this facies, with a predominance of more inflated forms with reinforced shell, the same kind as encountered in the reef facies. It is possible, however, that these latter forms were merely transported and buried in this facies, which is not very favorable for their habitat.

Somewhat different types of facies of shallow banks have been encountered in elevated areas. Particularly characteristic is the presence of sands and coprolite-nodular ooze, and a much reduced thickness. Its sediments are most widely distributed in the Schwagerina and Tastuba horizons along the axial part of Kazhatsk elevation, and also at Baranchino.

#### Facies at the Foot of Reefs and Banks.

This facies is characteristic for areas of accumulation of products of erosion from topographic elevations and occurs along their steeper slopes. Among the very diverse deposits of this facies two kinds are dominant: fine-grained oozes, and coarse detrital material. In the fine-grained oozes, diagonal bedding is frequently observed, and signs of over-squeezing and fluidity of the sediments is evident. Finely crushed organic detritus (particularly of bryozoans), and abundant crinoidal columnals are common. Small foraminifera and fusulinids are rare. Coarser clastics usually form only a few layers of breccias and conglomerate-breccias among the fine-grained rocks... Flora and fauna in the cementing material is not rich. This facies has not been fully investigated as yet.

Facies of Gently Inclined Slopes. The facies of gentle slopes of submarine banks is characterized by various organic-clastic limestones, which may be classified in the following order of gradual increase in the depth of deposition: (1) bryozoan-organic-clastic, (2) foraminiferal-fusulinid, and (3) crinoid-organic-clastic limestones. With progressively increasing distance from the parts of banks with most abundant life, there appears greater stratification and greater admixture of clay particles, resulting in lesser purity of the limestones. In the deepest parts of the slopes silicification occurs.

Organic remains in this facies are rich and diversified, except for a sharp reduction of all kinds of algae. Small foraminifera are represented by a large number of species and specimens, and as are fusulines. Sponges are not infrequent, and their spicules are occasionally encountered in great number. Bryozoans are usually found only in the form of detritus, and together with brachiopods build large coquina-banks. Crinoidal columnals are a constant integral part, while echinoid spines are rarely encountered and only in the shallower parts.

All foraminifera (including fusulinids), all crinoids, and some of the brachiopods probably were buried at places of their habitat. The position of bryozoans in this facies is not quite clear. The joint occurrence of bryozoans and brachiopods in Allaguvatovo area indicates a habitual distribution of the bryozoans in the brachiopod banks and brachiopod coquinas. It seems that a sufficient agitation of water which brings nutritious substances, a hard and comparatively firm substratum, and slow settling of clay particles, were favorable for the growth of bryozoans. Fragments of their zoaria have been transported down the slope beyond these banks; and some bryozoan detritus was probably transported to all parts of the facies from the higher parts along the inclines of the plateau where bryozoan growth is known to be particularly luxurious.

Part of the brachiopod material is also apparently of secondary nature, an accumulation of shells, but the manner of burial of the brachiopods in this facies remains unsolved.

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Facies of Great Depths. These facies are studied only at a few spots in the frontal part of the submarine plateau of Ishimbaevo region, and more completely in the area of Tara-Tau Mountain. To this facies D.F. Shamoï refers all micro-stratified clayey limestones which characterize the deep open sea to the east of the belt of the massifs. The great depths along the eastern and southern fringes of the Ishimbaevo submarine plateau have developed probably only since the end of Tastuba and the beginning of Sterlitamak time. The difference in depth is reflected by an increase to perhaps 300-400 meters up to Irgina time, and in subsequent time became augmented through the tectonic sinking of this region by 500-600 meters. It is quite natural that the facies of this region differs very sharply from the facies of the other regions. It is characterized by thinly stratified clayey sediments, in whose poor biota, the remains of nectone and planctone (radiolaria, remains of fishes, remains of plants) pre-  
dominate over those of benthos. Rare small foraminifera (Nodosaria, Tolopammina, Globivalvulina) and small bryozoan fragments are encountered in the detritus drifted in from elsewhere. To the benthos of this facies seemingly belong the sponges, whose spicules occasionally overcrowd rocks. Characteristic for the facies is phosphatization of the organic remains, presence of considerable amount of glauconite (in some beds) and very strong pyritization.

Facies of Strong Currents. This facies is characterized by accumulation of coarse clastic material. Its fragments have an "eaten out" appearance and only weakly rounded surfaces. They are tightly adjacent to each other, with nearly complete exclusion of cement. Organic remains are very scarce. Lateral change of this facies into algal subfacies of the submarine plateau at Smakaevo indicates that this facies belongs to comparatively shallow waters and strong currents. Shallowness of its depth is verified also by the not infrequent occurrence of fragments of siphonaceous green algae, bryozoans, and other organic remains, and algae, not known to live below 50-60 meters (150-180 feet) of depth.

... Thickness of the facies varies from 0.5 to 5 meters... It occurs in the Schwagerina horizon, and possibly in the lower zone of the Tastuba horizon."

<sup>35</sup> Distribution of Various Facies in Successive Horizons. On page 35 to 79 Rauser gives a detailed account of the distribution of the facies in each of the twelve differential biostratigraphic zones, and illustrates it by 12 maps which are here reproduced. (Figs. 3 to 14, see p.

Some details in this chapter have particular interest. In the description of the Tara-Tau area is mentioned "a fair abundance of fusulinids in their original occurrence in the biocoenoses of the slopes in middle Schwagerina time; their transport from the higher parts of the slope would be difficult to suppose in view of the absence of fusulinids in the local facies of submarine banks" (reviewer's italics).

In the analysis of the shallow water facies of the Shikhany zone and the Kuganak massif, it is deduced that distribution of the facies depends on speed of downwarping. In this area "bryozoan-brachiopod bioherms are encountered predominately in the south of the Shikhany belt, the corals -- in the northern group of Shikhany mountains, and the mizzia (siphonaceous green algae) and hydractinoid bioherms are particularly developed at Kuganak". Judging by the thicknesses of the corresponding deposits in these three areas, it is concluded (p. 64) "the brachiopod-bryozoan bioherms originated in the area of the slowest downwarping and slowest accumulation of the deposits; the coral bioherms: at the intermediate rate of downwarping, and hydractinoid: at the most rapid course of the same processes. The morphology of these three basic groups of reef-builders fully supports the observed facts: the brachiopod banks and the small basket-like zoaria of bryozoans must have been growing the slowest; the coral colonies faster, and the branching constructions of hydractinoids seemingly grew upwards the fastest."

Additional estimates of the depth at which some facies of Kinzebulatovo uplift originated is given on p. 73. The organic detrital limestone (of Irgina age) contains large amount of pyrite and small pebbles there occur fusenised (terrestrial) plant remains, two varieties of shamovells (= Tubiphytes), adnate and encrusting, various small foraminifer representatives of seven fusulinid genera, small sponge spicules; crinoidal columnals, and sea-

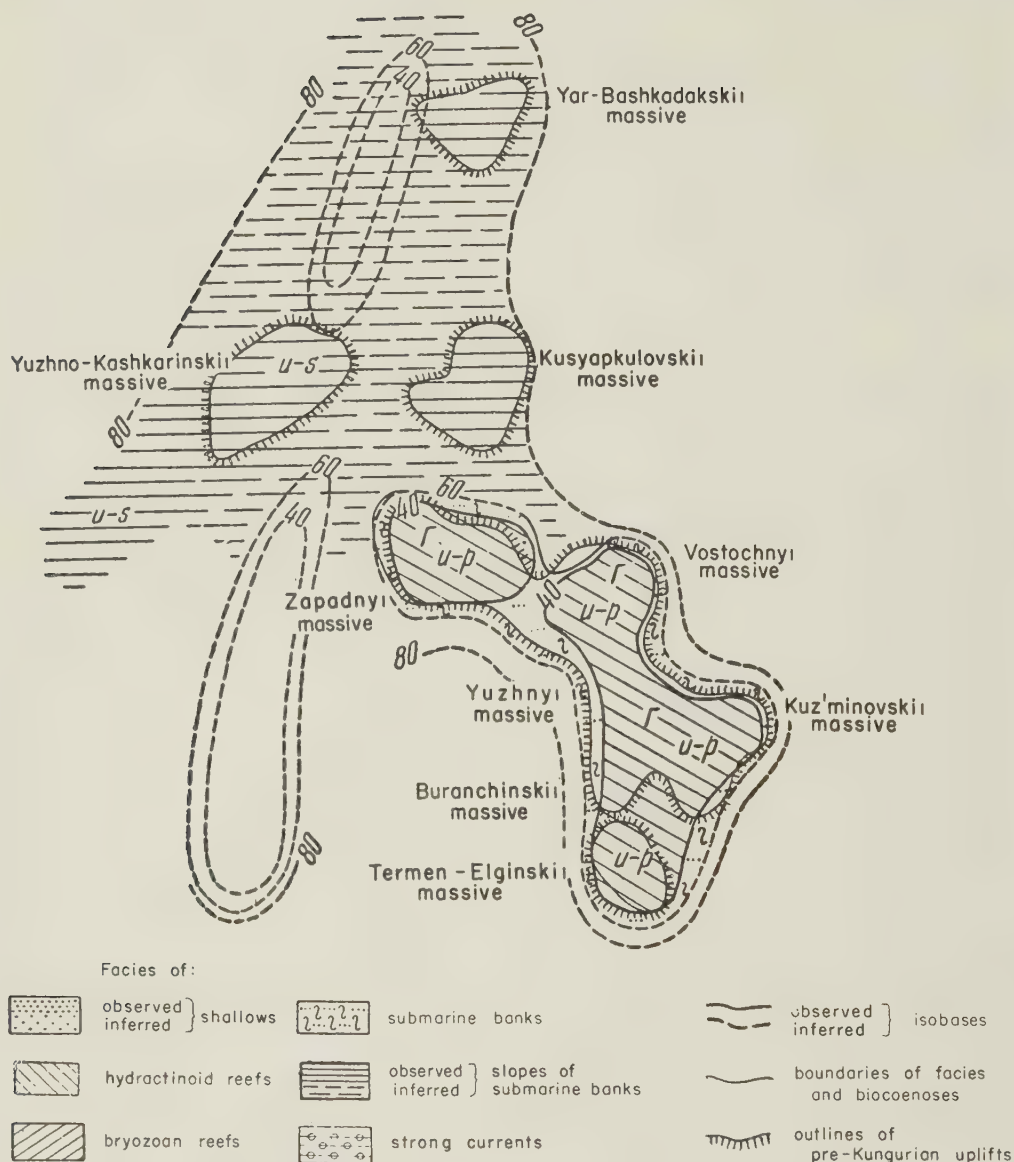


FIGURE 3. Distribution of biocoenoses of fusulinids and of facies in upper part of Sterlitamak horizon. Biocoenoses: u-p - with *Pseudofusulina urdalensis* and *P. plicatissima*; u-s - with *Pseudofusulina urdalensis* and *P. sulcatiformis*. Dominant groups of organisms: T- hydractinoids.

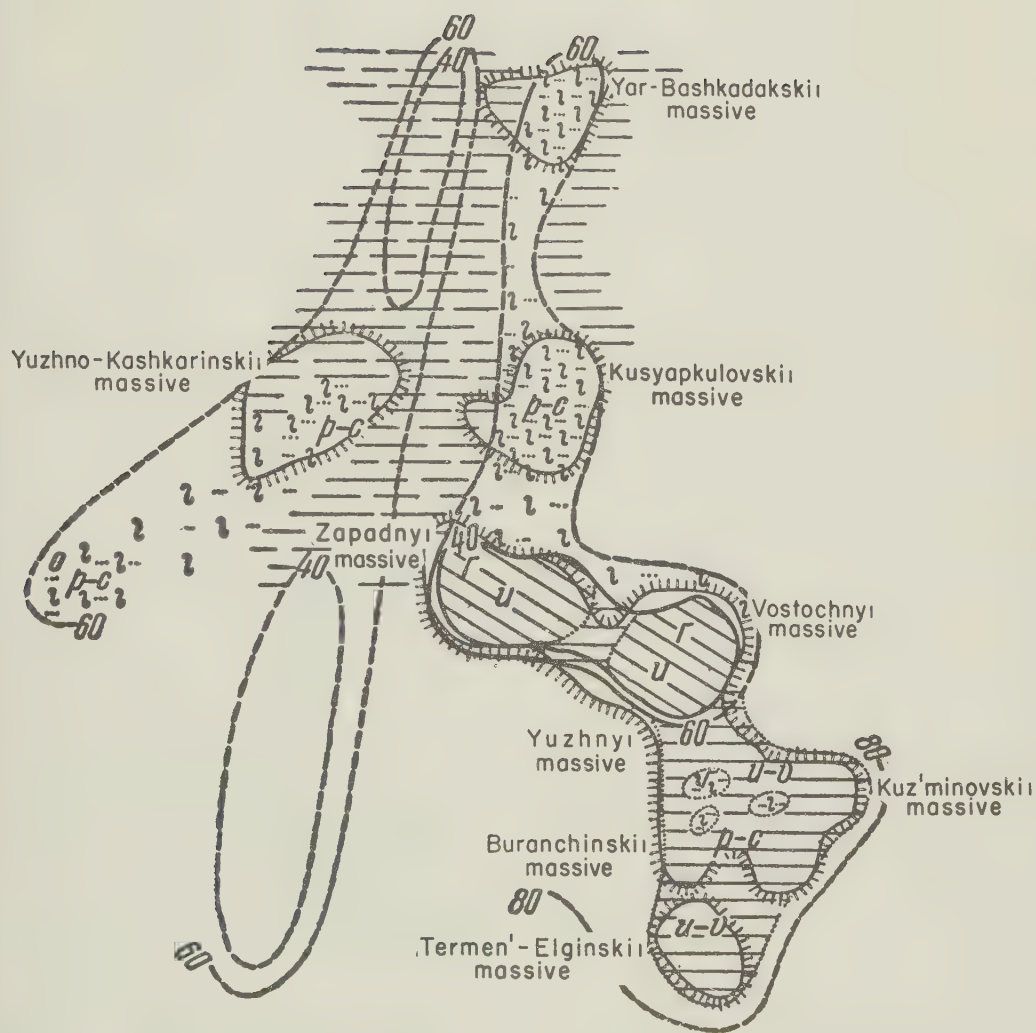


FIGURE 4. Distribution of biocoenoses of fusulinids and of facies in lower part of Sterlitamak horizon. Biocoenoses: with *Pseudofusulina urdalensis*; p-c - with *Pseudofusulina plicatissima* and *P. callosa* groups; u-v - with *Pseudofusulina urdalensis* and *P. verneuili* groups. Dominant groups of organisms: T - hydractinoids; 0 - mizzia (siphonaceous algae).

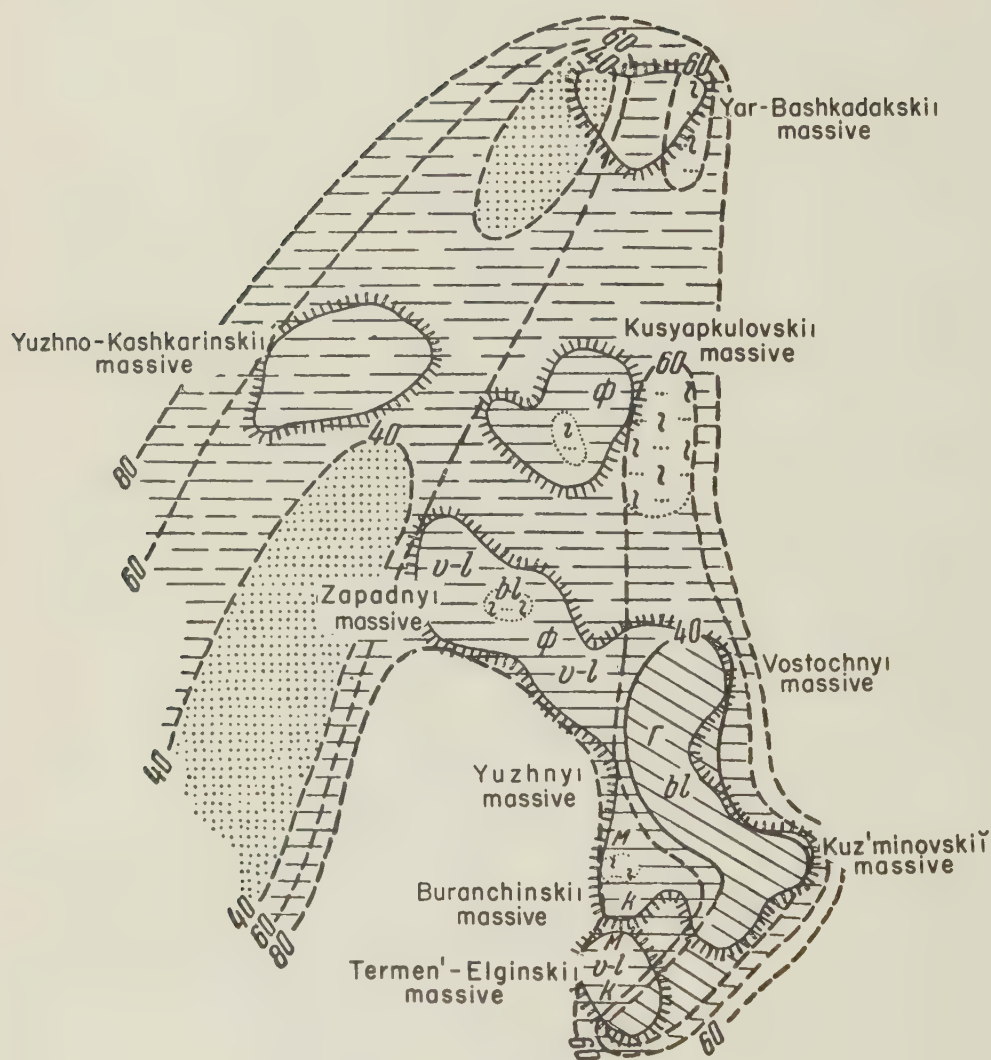


FIGURE 5. Distribution of biocoenoses of fusulinids and of facies in beds with *Pseudofusulina blochini*, upper zone of Tastuba horizon in massives; and in the whole zone elsewhere in Ishimbaevo region.

Biocoenoses:  $bl$  - with *Pseudofusulina blochini*;  $v-l$  - with *Pseudofusulina verneuili* and *P. longiarca*.

Dominant groups of organisms:  $r$  - hydractinoids;  $M$  - bryozoans;  $K$  - corals;  $\phi$  - fusulinids.

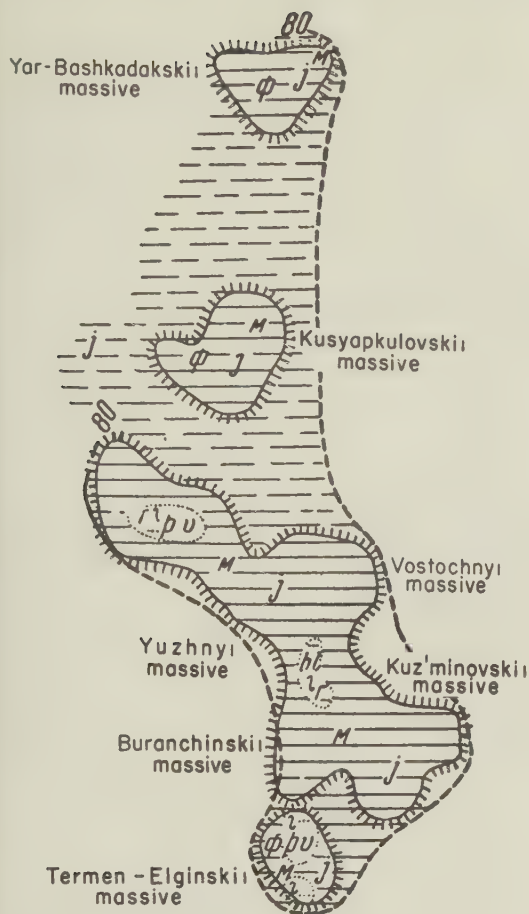


FIGURE 6. Distribution of biocoenoses of fusulinids and of facies in beds with *Pseudofusulina jaroslavlensis*, upper zone of Tastuba horizon. Dominant groups of organisms: T - hydractinoids; M - bryo-zoans; K - corals; Φ - fusulinids.

urchin spines. This fairly diversified organic life inhabited the bottom at not greater than 60-80 meters (180-240 feet) depth, which is indicated by the abundant algae (of all kinds), some sea-urchin spines and frequent foraminifera, and also the presence of pebbles."

Rausser points out that in a case when one of the observed contemporaneous facies (among those considered "bathyal") runs laterally and directly into another whose depth of deposition is known to be less than 100 meters, it would be hardly possible to allow for the other as much as 800 meters depth, which could have been otherwise supposed on the evidence of



FIGURE 7. Distribution of biocoenoses of fusulinids and of facies in beds with *Pseudofusulina confusa*, upper zone of Tastuba horizon. Dominant groups of organisms: T - hydractinoids; M - bryo-zoans; K - corals; Φ - fusulinids.

their present differential hypsometric levels. To illustrate her point she analyzes the following examples: "in an area of the eastern slope of the same Kinzebulatovo uplift... the thick argillites which build the eastern limb of the uplift are disposed hypsometrically at 400 meters below the above-described shallow water limestone (organic-detrital, of Irginia age). They contain a concentrate of organic remains, mostly sponge spicules and ostracodes, along the planes of stratification, and orientated along these planes. The ostracodes are thin-valved, not infrequently closed and frequently deformed. When loose the valves are buried in "valve into valve" manner, a sure evidence of agitated waters. This fact limits the probable conditions of deposition of semi-liquid ooze to a depth where water turbulence, no matter how slight, must have existed. Therefore, the present great difference in the hypsometric disposition of the facies, which amounts to 400 meters, could hardly be the original difference in depth and it

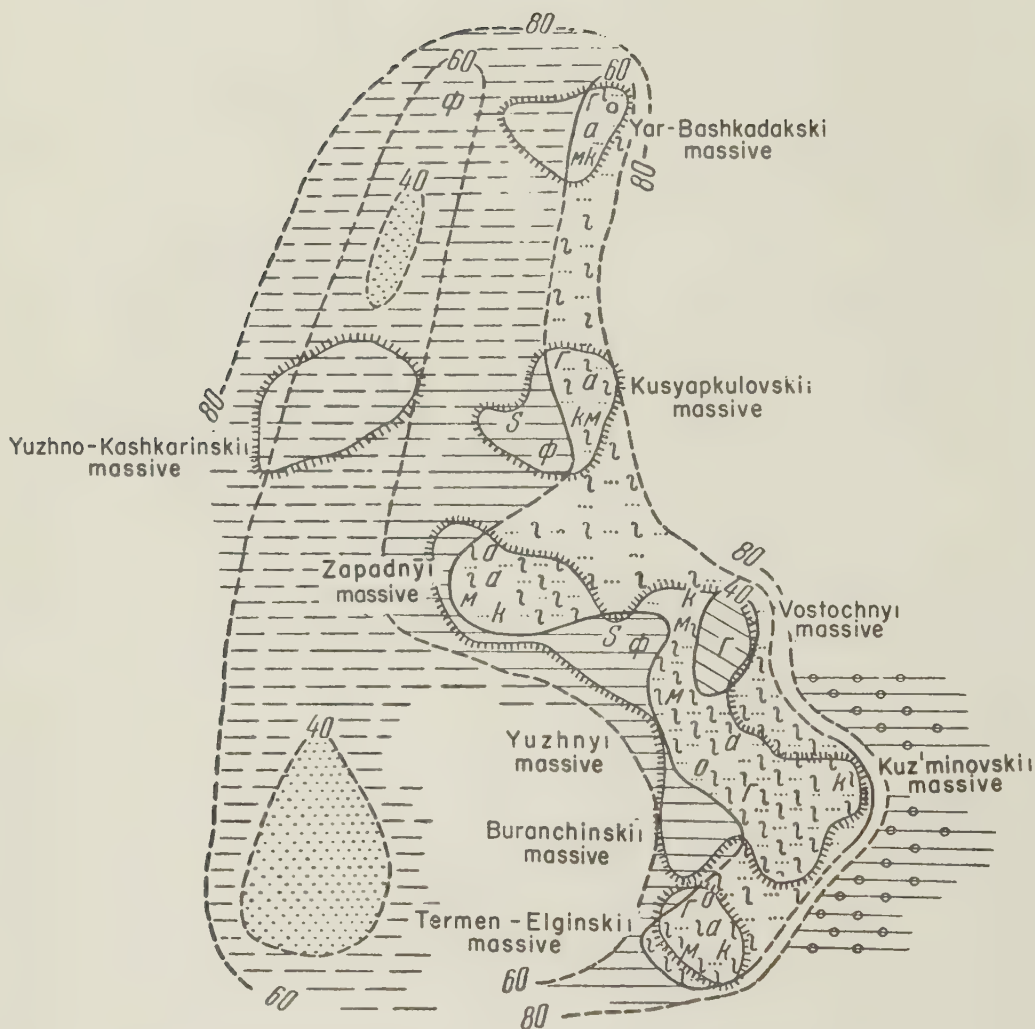


FIGURE 8. Distribution of biocoenoses and of facies in beds with *Pseudofusulina devexa* var. *acuta*, middle zone of Tastuba horizon in the massives; and in the whole middle zone elsewhere in Ishimbaevo region.

Biocoenoses: a - with *Pseudofusulina devexa* var. *acuta* and *Paraschwagerina*; S - with *Pseudofusulina sulcata* group.

Dominant groups of organisms: T - hydractinoids; M - bryozoans; O - mizzia (siphonaceous algae); K - corals; φ - fusulinids.



FIGURE 9. Distribution of biocoenosis of fusulinids and of diverse facies in middle zone of Tastuba horizon. Layers of *Pseudofusulina sulcata* and *P. lutuginiformis*.

Biocoenoses: m-c - with *P. Moelleri* and *P. conspicua*; m - with *P. moelleri*; m-l - with *P. moelleri* and *P. lutuginiformis*; SP - with group of *P. sulcata* and *Paraschwagerina*; Ss - with *P. sulcata* s. str.

Dominant groups of organisms: T - hydractinoids; M - bryozoans; O - mizzia (siphonaceous green algae); K - corals; φ - fusulinids.

must be concluded that the depth of deposition of the sediments in the eastern limb of the Kinzebulatovo uplift was much shallower, hardly more than 200-300 meters (600-900 feet). Hence a subsequent downwarping of this limb must be assumed.

Again, in the area east of the Tara-Tau Mountain there is a clayey-carbonate suite of rocks some 10 meters thick, capped by an organic-detrital limestone with *Parafusulina lutugini* complex. The presence of these Irginia age fusulinids, not known anywhere in the surrounding uplifts (from

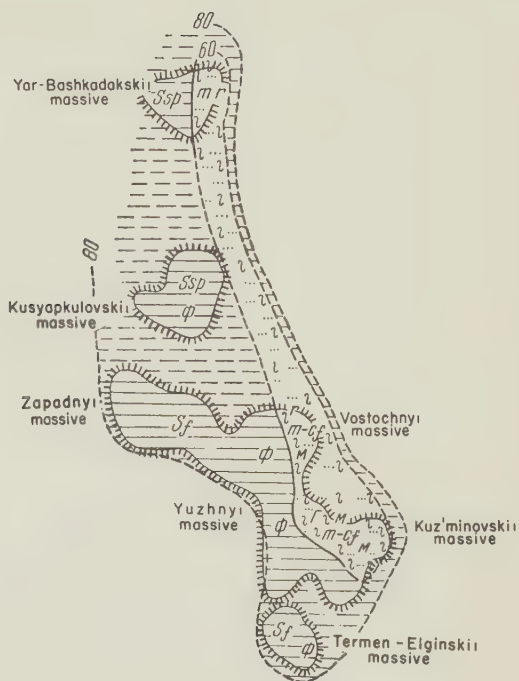


FIGURE 10. Distribution of biocoenoses of fusulinids and of diverse facies in middle zone of Tastuba horizon.

Layers with *Pseudofusulina conspicua* forma *firma* and *P. ishimbajevi* var. *correcta*.

Biocoenoses: m-cf - with *Pseudofusulina moelleri* and *P. conspicua* forma *firma*; mr - with *P. conspicua* forma *firma* and *P. mirabilis*; Sf - with group of *Pseudofusulina sulcata* and dominant *P. correcta* and *P. rauseri*; Ssp - with new forms of *P. sulcata*.

Dominant groups of organisms: T - hydractinoids; M - bryozoans; O - mizzia (siphonaceous green algae); K - corals; φ - fusulinids.

which they could have slumped, if present), forces one to doubt whether its present position at 900 meters relative depth could be an original one for the fusulines, which could hardly live below 100-200 meters (300-600 feet) of depth."

Characteristic rhythms were discovered in the Sarga deposits which contain breccias. Some rhythms consist of only two elements finely detrital limestone, and marl. The lower boundary of the limestone is sharp, and fusulinids, orientated by their long axis parallel to the bedding, usually occur. Occasionally this rhythm is augmented by the additional elements, detrital limestone with rock fragments,

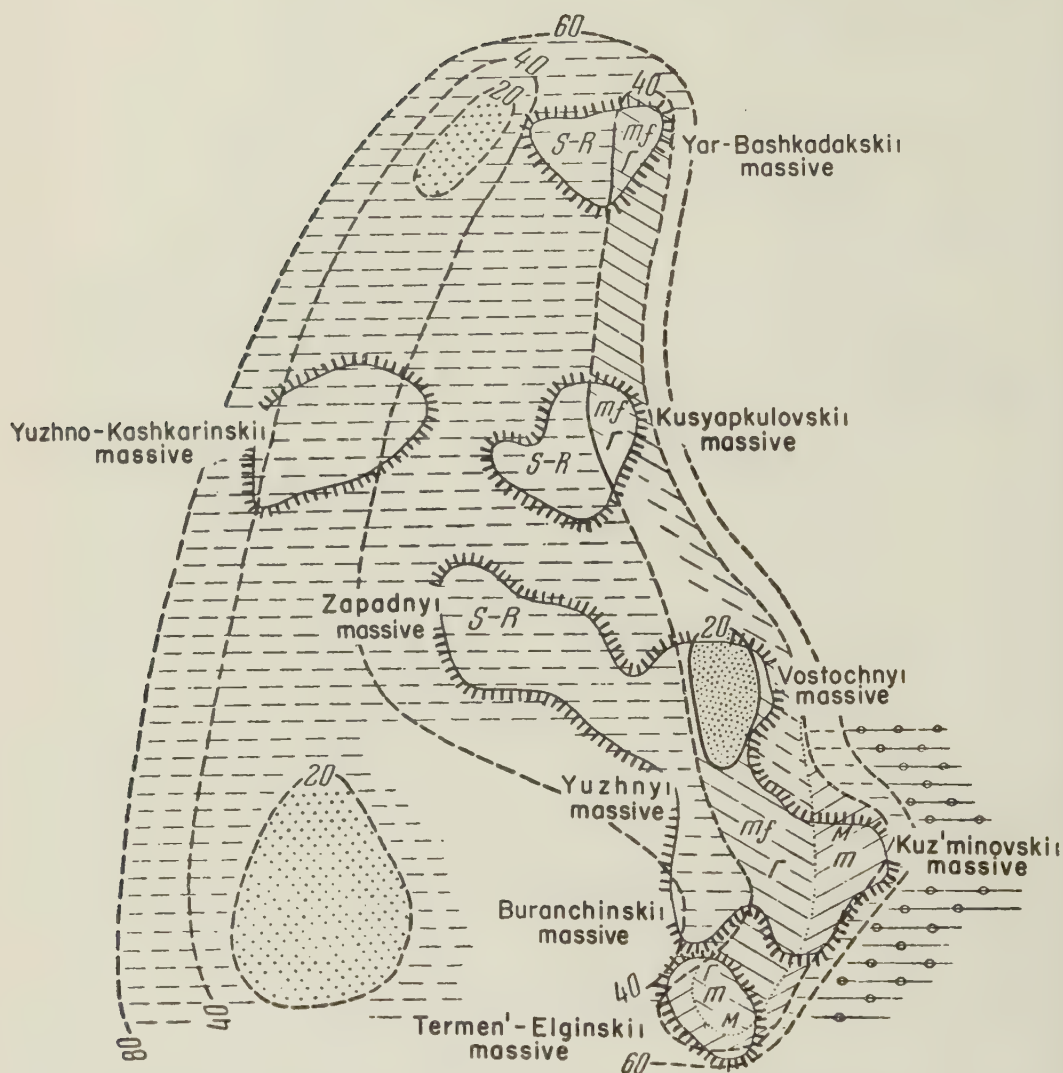


FIGURE 11. Distribution of biocoenoses of fusulinids and of diverse facies in upper part of lower Tastuba horizon with *Pseudofusulina moelleri* var. *firma*, in the Ishimbaevo massives; and in all lower Tastuba horizon to the west of them. Biocoenoses: M - with *Pseudofusulina moelleri*; mf - with reinforced forms of group of *P. moelleri*; S-R - with group of *Pseudofusulina sulcata* and rugosofusulines.

Dominant group of organisms. T - hydractinoids; M - bryozoans.



FIGURE 12. Distribution of biocoenoses of fusulinids and of facies in lower Tastuba horizon. Middle part with *Pseudofusulina conspiciua* and *P. moelleri*.

Biocoenoses: c - with *Pseudofusulina conspiciua*; c-S - with *P. conspiciua* and group of *P. sulcata*; m - with *Pseudofusulina moelleri*; m-S - with *P. moelleri* and group of *P. sulcata*; m-Se - with *P. moelleri* and reinforced forms of group of *P. sulcata*; mf - with dominant reinforced forms of *P. moelleri*; mf-cf - with dominant reinforced forms of group of *P. moelleri* and *P. conspiciua*. Dominant groups of organisms: T - hydractinoids; M - bryozoans; O - mizzia (siphonaceous green algae); φ - fusulinids; KP - crinoids.

and calcareous breccia. Transition between the elements of the rhythm is gradual, which indicates that the facies conditions of the whole rhythms are closely related. Thus the marls are here a neighbor facies with the shallow-water deposits, much as they are also in other sets of facies

#### Some General Observations

Abrupt changes of facies, such as at

the beginning of *Pseudofusulina*, *Sterlitamak*, and *Sargina* times, were apparently a result of regional tectonic movements. Smaller changes of facies in the course of time find their explanation in pulsation type of movements. In the *Ishimbaevo* area the smaller rhythm starts with shallower facies at the beginning and deeper facies in the second half. Amplitude and tempo of pulsating movements were nearly equal over the area, but in the southernmost area, where the reef sediments are of greatest thickness (See Fig. 17, p. 70) the sedimentation was of a fairly constant type, apparently because of full compensation of downwarping by the rate of deposition.

Greatest acceleration of pulsating movements is observed in late *Tastuba*, *Irgina*, and *Sarga* times.

#### 84 Paleogeography of the Sterlitamak - *Ishimbaevo* ante-Urals in Upper Carboniferous and Artinskian time

Rauser-Chernousova states that she prepared twelve paleogeographic maps which represent the paleogeography of the same twelve horizons for which she published her facies maps (here reproduced as figures 3 to 14). The facies maps cover only the area of the subsurface massifs at *Ishimbaevo*, while the paleogeographic maps cover the whole *Sterlitamak-Ishimbaevo* region. Of these maps she published only two (a combination of which is also here reproduced as Fig. 15, p. 68) these being "most complete," and illustrating "the most interesting moments" of the local geologic history: late *Schwagerina* and early *Sarga* times.

*Triticites* time. The *Triticites* sea continued to occupy about the same boundaries as its predecessor, the Middle Carboniferous sea. Some banks with reef-building organisms, mostly various algae and some bryozoans, were detected among *Triticites* facies in many uplifts: *Kinzebulatovo*, *Karly*, *Pastushinka*, and the southern part of *Shikhany* belt. This indicates the presence of positive structures in this belt already in *Triticites* time. In the *Ishimbaevo* belt too, some shallow water facies existed, though without reef-builders in them.

There are identical species of *Triticites*

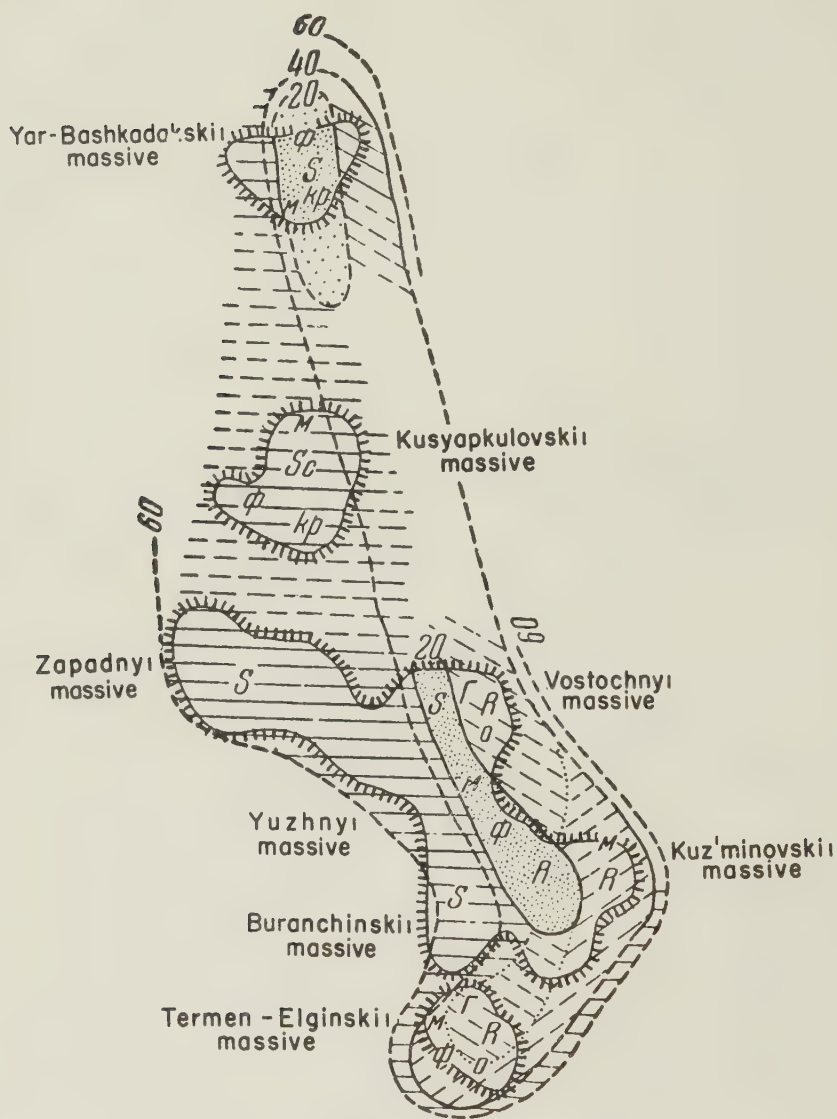


FIGURE 13. Distribution of biocoenoses of fusulinids and of facies in lower Tastuba horizon. Lower part with predominant rugosofusulines. Biocoenoses: R - with dominant rugosofusulines; S - with dominant group of *Pseudofusulina sulcata* and numerous rugosofusulines; Sc - with dominant group of reinforced *Pseudofusulina sulcata*. Dominant groups or organisms: T - hydractinoids; M - bryozoans; O - mizzia (siphonaceous green algae);  $\Phi$  - fusulinids; KP - crinoids.

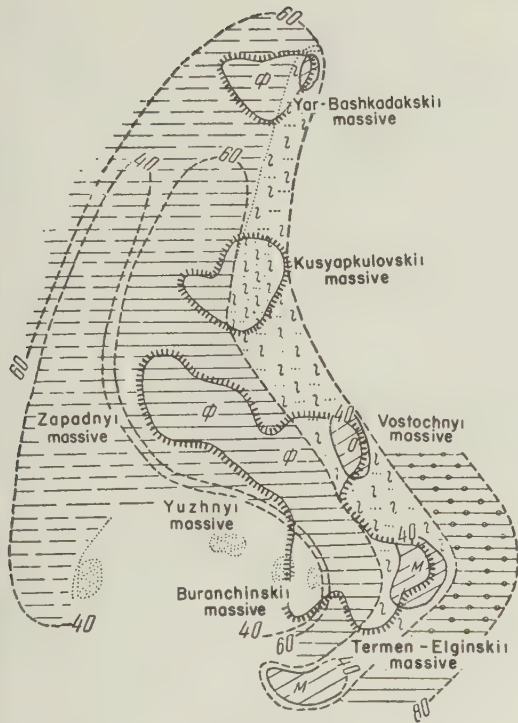


FIGURE 14. Distribution of biocoenoses of fusulinids and of facies in upper zone of Schwagerina horizon.  
Dominant groups of organisms: M - bryozoans;  
O - mizzia (siphonaceous green algae); Φ  
fusulinids.

in the first half of Triticites time almost everywhere in the European part of the USSR--a well-known fact. The difference in late Triticites time of the Triticites fauna of the discussed region from that elsewhere in the Russian platform and the Donetz basin indicates a certain degree of isolation at that time. Midget size and reduced number of species of Triticites in this region in late Triticites time may be explained by its proximity to the eastern shoreline of the Triticites basin.

**Pseudofusulina time.** The darkly colored carbonate-clayey sediments of Pseudofusulina time are characterized by constant admixture of brightly-colored flakes of fusenized and xelenized organic substance, and the presence of bituminous shales. They contain also pyrite, glauconite, sponge spicules (occasionally beds of spongolite), radiolaria, and phosphatic concretions (at Kinzebulatovo). These characters may indicate a sharp change to

cooler temperature at the beginning of Pseudofusulina time. The increase of terrigenous material is likely to mean greater discharge by the rivers and a sequence of tectonic moves in the Urals. The Pseudofusulina horizon in the western Urals lies disconformably over various horizons of the Triticites suite and the Middle Carboniferous. The differentiation of varied meridional belts and facies, and also of some differences within these belts along the north-south direction began to take place in Pseudofusulina time.

**Schwagerina time.** Most characteristic of Schwagerina time was an increasingly sharper differentiation in the western belt of the uplift as an almost uninterrupted stretch of submerged banks built by thick biomorphic and biohermic sediments; it may be likened to a barrier reef.

It was a sufficiently effective barrier in preventing the clayey particles of the eastern deposits from penetrating to the west.

Rausser selected the area of the Tara-Tau shikhan to illustrate the dynamic conditions of the earth's crust at the time of the growth of the local reefs (See Fig. 16, p. 69 ).

She shows two east-west sections of a selected area, one geologic (above) and the other "paleogeographic" (below). Complete development of the Triticites suite (the lowest in the sections) has been established both in the east and the extreme west of the area (line c-c). Transgressive overlap upon it by the Pseudofusulina horizon has been observed in the vicinities of Orlovka, which is east of Tara-Tau, gravel at the base of the horizon) and in the central part of the western belt (line b-b).

There was a general slow sinking of the central belt of the area during Pseudofusulina time, and somewhat faster sinking in its western part. It became still faster by middle Schwagerina time, during which great reefogenous masses were built in the Tara-Tau shikhan (line a-a). Much thinner deposits have accumulated at this same time in the shallow waters of the central part of the belt (line b-b), where sinking of the bottom had been the slowest. The rate of deposition of the sediments

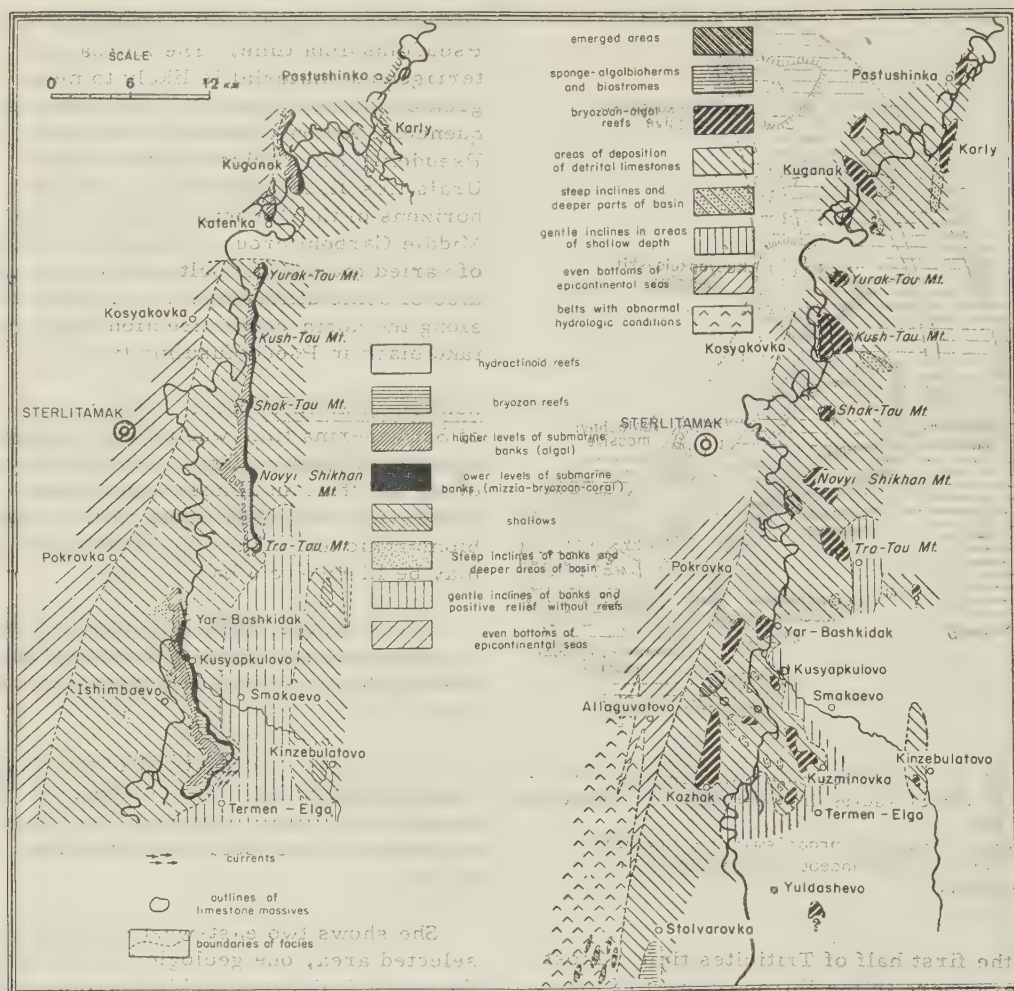


FIGURE 15. Schematic paleogeographic maps of late-Schwagerina (left) and early Sterilitamak (right) times at Sterilitamak-Ishimbayev area.

increased at Tara-Tau at a later phase of Schwagerina time so that the sediment of late Schwagerina time reached here 110 meters, while in the extreme west only 30 meters of the sediments accumulated at the same time. As shown in the paleogeographic profile, the accumulation of the huge reefogenous masses of the lower and middle zones of the Schwagerina horizon within the boundaries of the Tara-Tau shikhan (line a-a) simultaneous with the maintenance of small thicknesses of shallow water deposits in the central part of western belt (line b-b), could have occurred only under conditions of differential speed of the sagging with reef massifs originating on sagging limbs of a positive structure.

The same situation exists in the Ishimbayev region. To the west of the greatest accumulation of biomorphic limestones is a belt of shallows with some evidence of overwashing and overdeposition of the sediments, and also of their slower accumulation. In the south of the belt, in the area of Western Buranchino, the most shallow conditions can be postulated for early Schwagerina time, where the peculiar sediments of hydractinoid and coprolite-nodular foraminiferal sands were deposited. However, such deposits could have been formed also in the belt of warm currents.

More difficult to explain in the occurrence of fairly shallow facies of small

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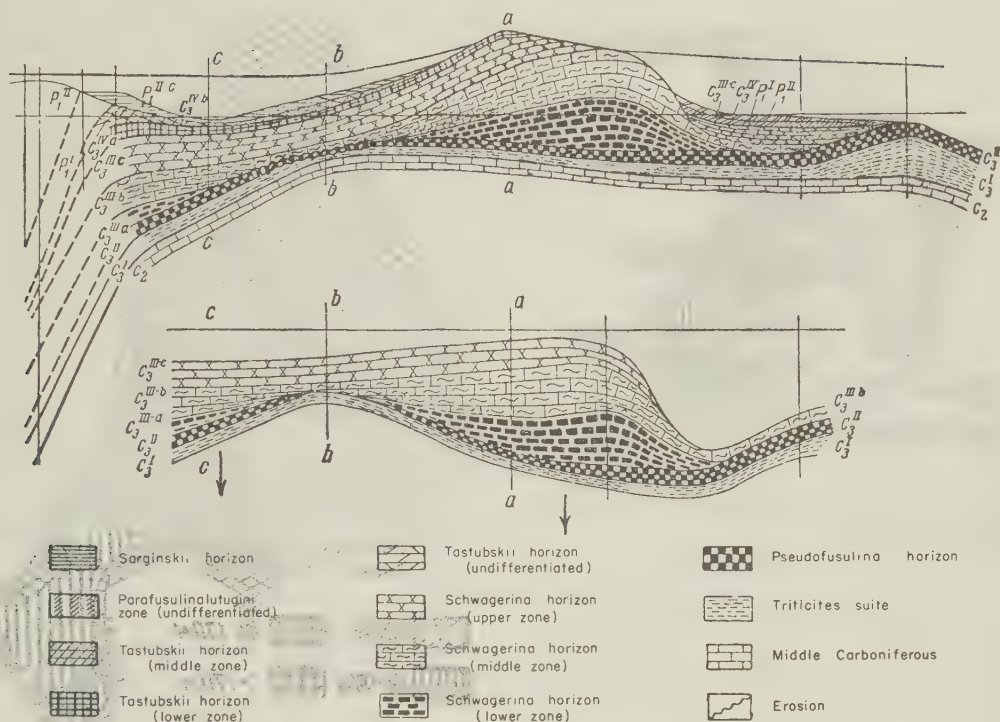


FIGURE 16. Geological (upper) and paleogeographical (lower) profiles of Tara-Tau area. Paleogeographic profile corresponds to the end of Schwagerina time.

thickness to the east of the region of the maximal accumulation of the deposits (at the bending of the eastern limb of the central elevation). Such sediments occur to the northeast and east of Tara-Tau. This phenomenon is reflected in the paleogeographic profile, as a second elevation in the east. To the east of the Ishimbaevo elevation there are also some deposits of detrital limestones with inlayers of breccias and conglomerates of the Schwagerina horizon; these could not possibly be interpreted as being of deep water origin, in view of the presence in the cement of the fragile mizzias, siphonaceous algae and frequent shamovells (= Tubiphytes), which build substantial inlayers. Therefore, the accumulation of a 500 meter-thick suite of the lower and middle-Schwagerina deposits, under conditions of downwarping of the eastern limb of the Ishimbaevo uplift, must have been accompanied by a substantially slower sinking of the Smakaevo area.

Rauser-Chernousova believes that "it is very probable that the distribution

of the facies has been dependent not only on the differential speed of downwarping of the ante-Ural sag, but also on the marine currents. The preponderance of Glomospira-Tolypammina and coprolite-nodular limestones, calcareous sand and pebbles in the sediments of the western belt of shallows, and also in the northern massifs in medial and late Schwagerina time, may be tied-up either (1) with slowing of sedimentation in the area of uplift, or (2) with cold currents along the western slope of the massifs from the north to the south. Warm currents may also be expected in the opposite direction, along the southern and eastern shores in the south where southern terminals of the banks projected conspicuously in the sea (Fig. 15).

Tastuba time. The Tastuba sea occupied the same surface as the Schwagerina time sea, and the sediments of the latter time succeed those of Schwagerina time without any pronounced change. The fossil organisms remain also about the same; great similarity is noticeable among the fusulines,



FIGURE 17. Map of thicknesses of upper zone, Schwagerina horizon.



FIGURE 19. Map of thicknesses of Sterlitamak horizon.

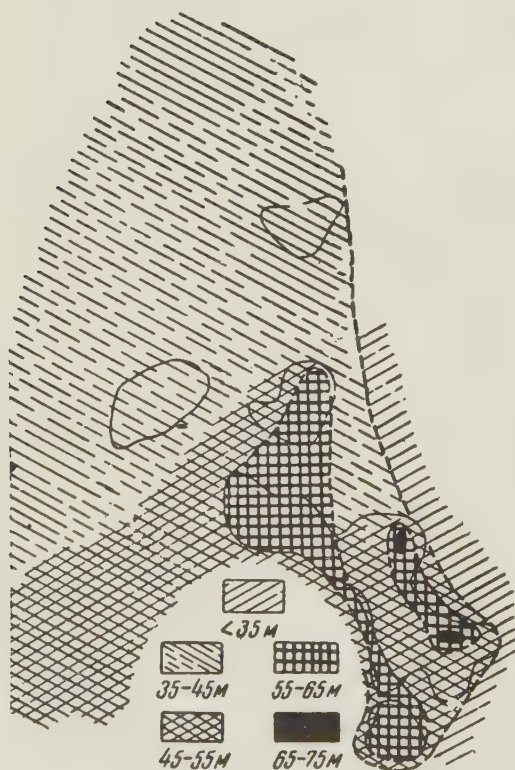


FIGURE 18. Map of thicknesses of middle zone, Tastuba horizon.

small foraminifera, corals, and brachio pods. Many new forms appear in Tastuba time only among the Bryozoan, but this is a consequence of a wide development, at this time, of bryozoans bioherm, in which many edemic and purely local species evolved. The predominance of carbonate precipitations, their purity and lack of clayey material, and also wide development of coral facies (which do not tolerate muddy waters), all point to continuation of comparative tectonic quietness at this time. However, frequent change of facies (in the vertical direction) indicate some pulsating movements, their amplitude increasing toward the end of Tastuba time. The area was generally shallow in the early Tastuba and even shallower at the end of Tastuba time. At this time uplift of a larger part of the southern Shikhany belt occurred, and considerable sinking of the extreme western fringe of the Tara-Tau belt occurred, as testified to by great thickness of Tastuba sediments. The major changes in the distribution of the sea in connection with all of these events indicate that Tastuba time and especially its

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end was a critical time in the geologic history of the region, and would be a logical boundary between the Carboniferous and Permian eras. As far as the faunas are concerned the late Tastuba time witnessed the development of some Artinskian forms. Thus, some characteristic Sterlitamak species evolved at this time, and the whole aspect of fusulinid fauna becomes nearly uniform and approaches that of the Artinskian.

Sterlitamak time. The beginning of Sterlitamak time is distinguished by a sharp change of facies and faunas, and the initiation of a wide transgression. Clayey-carbonate sediments take the place of the dominant carbonate deposits of Schwagerina and Tastuba times. Increase of terrigenous clastics is accompanied by an increase of brightly colored flakes which according to Radchenko are altered remains of terrestrial plants; also an increase of sponge spicules, radiolarians and pyrite is noted.

The initiation of Sterlitamak time is marked by an orogenic phase (Gerasimov, 1937). Dubrovin (1936) believes that at this time the eastern (Vostochnyi) massif was elevated above sea level, while no such elevation can be noticed in the western (Zapadnyi) massif.

Because of the abrupt change in the fauna and fairly great changes in the paleogeography, the beginning of Sterlitamak time manifests the end of Carboniferous and the beginning of Permian time.

Burtsevka time. No substantial changes in the distribution of the sea can be noticed, and some quieting-down of the tectonics at the beginning of Burtsevka time is indicated. Biocoenoses of this time are characterized by an extraordinary monotony and poverty (of forms), but in spite of this the Burtsevka fusulinids show a sharp facies and geographic differentiation, a feature characteristic of Permian time.

Irgina time. A progressive further impoverishment of organic life characterizes this time and a noticeable increase of clay in the sediments, and large amounts of vegetable debris and of pyrite occur. It seems natural to connect these general paleogeographic changes with a new intensification of the tectonic moves in the Urals.

The configuration of land and sea remains substantially as in Burtsevka time, but most characteristic is the shallowness of the entire territory in the second half of Irgina time and the corresponding increase of erosion. The appearance of some specific bryozoan and algal submerged banks with biohermic type of sediments is characteristic.

Sarga time. "Sarga time has much in common with Sterlitamak and especially with Pseudofusulina time. However, probably because of more abrupt cooling in that time, the Sarga deposits became extraordinarily enriched with spicules of sponges (not infrequently layers of spongolites), radiolaria, and land plant remains. Nodosariids and ammonitids became predominant among foraminifera, once again glauconite and phosphatization of fossils appear, and clay particles also occur in the sediments. Similarity to Pseudofusulina time appears also in the character of bitumen, which according to Radchenko belong to humic (guminovye) substances, indicating higher plants as a source of organic material in the sediments. Yet in Sarga time not only clayey-carbonaceous sediments were widespread, but also coarse clastics occur in large amounts. At this time in the ante-Uralian sag pronounced upheavals and erosion of the previously deposited sediments are observed."

Wide areas in the sag became exposed, and breccias and conglomerates became extraordinarily widespread; but in a later Sarga time the sea submerged nearly all of the isles again.

Soshkina (1945) uncovered convincing evidence of early Sarga time erosion in Ishimbaevo massifs by the presence in shikhany of a prolonged continental weathering in the form of weathering crusts, ancient karst and cracks filled by the late Sarga sediments, etc. Soshkina, Trofimuk and Gubkin visualized the origin of the cladochthonous cover as a result of late Sarga time marine transgression.

Shamov (1938) and Khvorova (1937) consider the Sarga deposits, which gradually change into the overlying Kungur anhydrites, to be shallow water deposits, but believe that the underlying Irgina deposits to be bathyal, with depth of deposition down

to 1000 meters. Rauser-Chernousova disagrees with Khvorova's reasonings about the latter estimates, and considers it open for further verification.

#### Basic Conclusions

1. The Carboniferous and Artinskian organic remains in the Sterlitamak-Ishimbayev region show periodicity in the development of the marine organisms, obviously related to the geological history of the Urals and the near-mountain sag.

In the course of geologic time the principal role in the reef building changed from hydractinoids, through corals and bryozoans, to algae. The change is particularly well expressed in the Artinskian epoch: in its earliest (Sterlitamak) time there was an extraordinarily rich development of hydractinoids and corals; in Burtsevka and Irkina time, bryozoans became reef-builders; and in Sarga time, algae reached their greatest development, together with the associated "nubecularia" type of foraminifers. The same sequence is detected in post-Gjelian time, though with lesser clarity. Hydractinoids occurred in greatest number at the end of Schwagerina time, corals and bryozoans were particularly widespread in Tastuba time, and a great number of blue-green and adnate algae appeared by the end of Tastuba time.

This sequence of the principal reef-builders apparently has been controlled primarily by the chemistry of the basin and the nutritive contents of its waters, as there seems to be no reason to ascribe it to changes in depth or temperature of waters. The first stages in the outlined development of the organic world are coincidental with initiations of major sedimentary cycles. Each transgression (Schwagerina and Sterlitamak) has meant rejuvenation of chemical contents in the water, and of its nutritive character, such as increase in the influx of terrestrial plant detritus, etc., and this has created favorable conditions for life. However, completion of cycles in the development of reef-building organisms seemingly did not always coincide with an end of sedimentary cycles, if the latter is determined only by a change in the lithology of rocks, which was induced by tectonic movements. Thus, in spite of major upheavals and substantial

redistribution of waters in Sarga time, algae became widely distributed, a direct indication of a dropping-off of the quality of life conditions. It may be supposed that at this particular time a change in salinity and in general chemistry of the water took place, a transition toward the Kungurian basin to come.

The detected sequences may be considered of regional significance, and permit the determination geological time on its evidence, though only in the terms of major stratigraphic units. Thus, within the Artinskian of the discussed paleozoographic region, dominance of bryozoans will always indicate Burtsevka and Irkina time; dominance of hydractinoids--Sterlitamak time; and so on.

A similar sequence of the same reef-building organisms is established for the deeper parts of Schwagerina and Tastuba time basins, as per the evidence from the detailed facies maps. The organisms in the shallowest bottoms are hydractinoids, next to which are corals and bryozoans, and the deepest bottoms are occupied by algae, in this case by shamovells (= Tubiphytes).

The same sequence of the organisms can be observed in conditions of differential sagging: where faster sagging took place hydractinoid bioherms have developed; where moderately fast sagging took place, corals are encountered; and under conditions of slowest sagging, brachiopod or bryozoan biostromes occur.

All these observations permit the following conclusions: Hydractinoids indicate shallowest waters, most favorable conditions of life, and maximum sagging, (which means maximum rate of accumulation of sediments). Corals flourish at a more moderate development of these same factors. Bryozoans indicate lesser rate of sagging and accumulation of sediments, greater depths, and less favorable conditions of life. Finally, algae and "nubecularia" type of foraminifera indicate still less favorable conditions for life, slow rate of accumulation of sediments, and occasionally also slower sagging of an area, and greater depths.

Besides, as the example of bryozoans

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and foraminifers indicate, some species and subspecies serve as indicators of facies conditions and of geologic history of habitations. It also shows that organisms are more sensitive to changes in the water than in the sediments.

2. The evidence of the geologic history of the region and its inhabitants indicates that the most crucial moment indicative of the Carboniferous-Permian boundary is that between Tastuba and Sterlitamak time. It also indicates that the use of the Sakmarskii stage as a stratigraphic unit is inconvenient, because neither its lower boundary (base of Schwagerina horizon), nor the upper boundary (top of Sterlitamak horizon) correspond to the most sharply-expressed paleogeographic changes.

In paragraphs 3, 4, and 5 are summarized data on distribution of facies, lithotopes, and formations (in the faciological sense) in relation to three meridional geological belts of the region, and in 5 some peculiarities of their geological structure are explained on the evidence of faciological analysis.

3. Within the studied part of the pre-Uralian sag and the eastern edge of the Russian Platform there are three clearly indicated zones of formational distributions. In the wide, eastern or Karlinsk-Kinzebulat zone of formations, the majority of uplifts are characterized by (1) incomplete stratigraphic (columnar) sections, (2) evidences of discontinuities, erosion, and drainages of uplifts, (3) small thicknesses of horizons, (4) shallow water carbonate sediments with facies of submerged banks of considerable depth. Characteristic of the sags are chert-clay-carbonate sediments. In the narrow central zone, or the zone of reef formation, (columnar) sections are observed in the uplifts and an absence, as a rule, of interruptions and erosion, large thicknesses of deposits, and wide distribution of biohermal and biostromal sediments is noted. In the submerged parts of this zone are observed calcarous breccias and clay-carbonate, less frequently chert-clay-carbonate deposits. In the western, Allaguvatovo belt of formations, there are observed complete (columnar) sections with considerable thickness; among these sediments predominate carbonate and detrital kinds, not infrequently with clayey particles.

Dolomitization and silicification are also observed.

4. Belts of distribution of lithotopes of these three zones of formation cross the latter (zones) along the lines from southwest to northeast. This direction is determined by the increase of the rate of sinking toward the south of the ante-Uralian sag and the eastern edge of Russian Platform, widening of the sag in the same direction, and growth in the intensity of mountain-making-processes in the north-south direction. Examples of changes of lithotopes in such directions are as follows: increase in thickness and clay contents of the sediments to the south and southwest, and increase in contents of carbonate in the sediments toward the north and northeast, and the appearance of reef facies in the northeast (Nikolaevka) and the southwest (Stoliarovka).

5. Detailed study of the facies of positive structures of the eastern and central zones disclosed some general peculiarities of the geologic character of these structures. The southern ends of the uplifts and of the separate structures within their boundaries happened to be on a higher hypsometric level, and on them are observed the maximal reef-building, greatest thicknesses, and at the same time largest interruptions, washouts and erosion. Examples of such mutual relationships were cited not once (Karlinskaya and Pastushinskaya structures, Severno-Pokrovskii and Kuganakskii massifs, Shikhan zone, Ishimbai uplift). These evidences are most clearly traced in the Shikhan uplift in its entirety. It is also observable within the borders of individual shikhans, which are near-crest (prisvodovye) elevations.

These evidences may be explained only by maximum amplitude of positive as well as negative movements of these sectors, that is by maximum mobility of southern terminals of separate structures and of positive zones in their entirety. The greatest elevation of southern (or distant ends of elevations in their relation to their northern (or proximal) ends and their maximal mobility is emphasized particularly by simultaneous sinking to the south of the bottoms (lozhe) of sags adjacent to these elevations, and indicate an increase of amplitude of dislocation to the south. The

apparent preservation of the arched part of the uplift in its unaltered original position; and some elevation of its southern part which accompanied general sinking of this same part, create an impression of a lag in sinking of the arched parts from the general sinking, that is some sort of inertia of massifs or their resistance to the overall downwarping of the ante-Mountain sag. Perhaps the location of the reefs in these mobile sectors contributed to an increase of this inertia.

103 A second peculiarity, at the present established only in the central zone, is a frequent complication of the southern ends of the structures by secondary folding, or by their bifurcation. In such sectors, very shallow deposits with evidence of interruptions and greatly decreased thicknesses are developed. Examples of such conditions can be seen in the southern sectors of Jurack-Tau, Kusk-Tau, and less obvious in Shak-Tau; evidences of bifurcation of the arched parts are in evidence in the Tara-Tau area; particularly clearly expressed in the bifurcation of a single Schwagerina time elevation of the Ishimbaevo uplift into two, Kazhaskii and Ishimbaiskii at Sterlitamak time. It seems that this peculiarity is also conditioned essentially by a greater mobility of its southern terminals.

6. One of the fundamental problems of the investigation was to clarify regularity in distribution of the Ishimbaevo limestone massifs.

The majority of the investigators of Sterlitamak-Ishimbaevo region express the view that the initial movement in the formation of the reefs was a hypothetical early-Carboniferous fold, gentle and wide. The subsequent development of the reefs was explained by these investigators as a result of greater speed in the accumulation of the sediments by reef-building organisms against a background of the quickly-sinking ante-Uralian sag.

There is no doubt that rapid sinking of possible foundations for reef structures, as well as being sufficiently far removed from an area of terrigenous sedimentation creates a basic situation for reef-building. Indeed, there is evidence of a sufficiently rapid sinking of the ante-Uralian sag and

of the adjacent part of the Russian Platform; and there is an evident connection between gradually increasing speed in the sinking of the ante-Uralian sag toward the south, and the resulting gradual increase in this direction of thickness of sediments and increased reef-building. Additional evidence of the same kind is provided by the maximal reef-building in the most mobile southern terminals of the uplifts where sinking was most rapid. The localization of the reefogenous rocks along the eastern edge of the reef zone is also a result of comparatively greater mobility of a transitional stretch of land from between the stable, slightly sagging Allaguvatovskaya belt and the rapidly sagging eastern belt. In this stretch of land an acceleration of sagging is especially noticeable, and such sagging determines accumulation of reefaceous masses exactly along the eastern limbs of all elevations of the reef belt in Schwagerina time. Similarly, a subsequent faster sagging of the western limb of the Shikhany belt induced shifting of reef growing conditions toward the western limb of the elevation in Sterlitamak time. Finally, there are examples of reef building in the course of latitudinal saggings, such as occurred in Southern Kashkara, Kosyakovka, Zabelskoe, and possibly in Dmitrovo and Nikolaevka areas.

The observed facts indicate that the postulated rapid sagging of the reef foundations alone is insufficient to account for the origin of reefs, and investigations have proved, for the first time, the existence of some actual absolute elevations within the boundaries of all reef massifs...the distribution of the facies in Ishimbaevo and Shikhany elevations, and in other structures has shown that the building of these positive structures was a lengthy process through the course of Upper Carboniferous, Artinskian, and Kungurian stages of time.

The positive (uplifted) structures were favorable for the origin of reefs as their rise must have resulted in intensification of movement of waters, optimal temperature for conditions for life, better gaseous regime, larger contents of  $\text{CaCO}_3$  in water, clearer water, large amount of nutritive substances in it, and so on. At first, in Carboniferous time, the area of the reefs was merely a shallow bank with a wide and flat surface. The prevalent distribution of

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the facies of that time was in the form of long belts, and not concentric. Differentiation of isolated massifs in the reef belt occurred only since Sterlitamak time as a result of biohermic sedimentation and (local) tectonic movements.

7. The present configuration of the massifs is determined not only by reef-building processes, though reefogenous rocks have considerable significance in differentiation of the processes of erosion, as these rocks offered greatest resistance to it. The basic factors which determined the present configuration of the massifs were tectonics and erosion; the tectonics was primary factor, as it determined both reef building and erosion... The present relief of the massifs has been substantially influenced by the continued downwarping of the Carboniferous-Artinskian sags in Kungurian time. It resulted in the subsequent over-emphasis of the pre-Kungurian erosional relief.

8. There was no major migration of reef facies toward the west commensurable with the migration in this direction of the axis of the ante-Mountain sag. In the course of Upper Carboniferous and Artinskian time the region of the maximal reef-building in the Sterlitamak-Ishimbaevo ante-Urals was practically stationary. Small scale shifting of reef-building was controlled by the tectonics of separate structures or of a wider area.... Westward shifting of reefogenous sediments of Pseudofusulina, Sterlitamak, and Sarga time was apparently induced chiefly by more intensive orogenic movements in the Urals, and connected with westward migration of the boundary between clear and muddy waters. The reversed, eastward shifting of the centers of the reef building in Burtsevka time (in the Dmitrovo area) and Irgina time (biomorphic limestones of villages Zabelskae, Kinsebulatovo and Nikolaevka) indicate a possibility of reef-building also to the east of the principal reef belt at the periods of quiescence of the local tectonical regime. There are some undoubted general shifting of the area of the maximal reef building processes westward in the major sectors in time, paralleling the formation of the ante-Mountain sag. However, the migration of the facies was not simply a result of an uninterrupted westward shifting of the axis of the sag, but a

function of the complex tectonic history of a wider territory.

### Comments on Stratigraphy (by Reviewer)

The stratigraphic differentiation of the Russian marine Upper Carboniferous and Lower Permian is peculiarly different from the American: while geographic names are used for some major stratigraphic units, other units of the same magnitude are named after their most characteristic fossils. There is a historical reason for this apparent inconsistency. Stratigraphic differentiation of the exposed limestone massifs on the evidence of their lithology and megascopic fossils alone was a difficult problem. Major stratigraphic errors resulted from an early attempt to base the differentiation on these means (Th. Tschernyshev's divisions). The present stratigraphic differentiation became possible only after an advanced study of the stratigraphically reliable microfossils, particularly fusulinids.

The easiest to recognize among them is Schwagerina princeps (in Moeller's sense), because of its subspherical shape. The lateral persistence of this fossil in the same, fairly narrow thickness of rocks, assured its wide recognition as an excellent horizon marker not only in Russia but also in other countries of the World, notably America, China and Japan. Because other fusulinids occur widely in the limestones and calcareous shales almost throughout the upper Carboniferous (= Pennsylvanian) and lower Permian of the Northern Hemisphere, the study of these fossils, particularly in thin sections (under microscope) became a highly specialized branch of modern micropaleontology. Scores of genera and subgenera, and hundreds of species of fusulinids became gradually recognized. However, because different characters were used for generic differentiations by different paleontologists and at different times, the taxonomy of the fusulinids became highly complex and far from being uniform. This is particularly so with the fusulinids encountered in the transitional rocks between the undoubted Upper Carboniferous and the Permian: nearly all of the fusulinids in these rocks, at one time or another, were classified by reputable paleontologists in the genus Schwagerina

Moeller, and no agreement on its meaning is yet in sight.

There are two principal rival meanings of the generic name Schwagerina, which in turn imply differences in the meaning of the names for the related fusulinids: Pseudofusulina, Pseudoschwagerina, and Paraschwagerina. One of these two meanings of Schwagerina is in Moeller's sense (1880, 1882) and the other is in Dunbar and Skinner's sense (1936). In 1936 Dunbar and Skinner coined a new generic name Pseudoschwagerina for Schwagerina in Moeller's sense, and proved to their own satisfaction that the name Schwagerina should be applied to the fusulinids previously (in 1934) named by them Pseudofusulina; but Rauser-Chernousova and her associate in the study of fusulinids continue to use for the latter fusulinids the name Pseudofusulina. Upholding and developing the traditional use of Moeller's understanding of the genus Schwagerina in the stratigraphy of the Volga-Ural region, Rauser uses the term Schwagerina horizon (with a symbol  $C_3^{III}$ ) for the rocks characterized by various species of Schwagerina in Moeller's sense. The underlying rocks are called by her Pseudofusulina horizon (with a symbol  $C_3^{II}$ ), after the characteristic species of the genus Pseudofusulina, and which Dunbar and Skinner would refer to Schwagerina. The genus Pseudofusulina (= Schwagerina D. & S.) is encountered also in the Schwagerina horizon of Rauser, and is also well distributed through the still higher Tastuba or Tastubskii horizon (with a symbol  $C_3^{IV}$ ). If all the fusulinids classified by Rauser in Pseudofusulina were transferred to Schwagerina, as per Dunbar and Skinner is understanding, the vertical range of the latter genus would expand greatly. What they suggest is to change the name of the Schwagerina biostratigraphic zone to Pseudoschwagerina zone.

#### Comments on Paleontology (by Reviewer)

Algae. The presence of algae in the Ishimbaevo and Shikhany massifs has been frequently recorded, but only a few previously described (Makhaev, 1950). Hence Rauser-Chernousova's notes and illustrations on algae deserve close scrutiny.

Blue-green Alga A. Rauser-Chernousova

applies an informal term "alga A," and "Blue-Green alga A" to complexly interwoven filaments of slightly variable width. The filaments in her best illustration (1950; Pl. 4, fig. 2) vary from about 20 to 40 microns wide, which is the width (aver. 30 microns) of the filaments in the "coarse tubes" in the Osagia sp. from the Fort Riley limestone and the Big Blue Series of Kansas (Johnson, 1946, Table 3 op. 1104). Johnson identifies them with Girvanella (footnote to p. 1104). The character of the interwoven tubes in the illustrated examples of the Osagia (Johnson, 1946, Pl. 5, fig. 3 and 6) is much like Rauser's "alga A," and both these and Kansas filaments are associated with an alnate "Nubecularia"-like foraminifer. Hence "alga A" may be at least tentatively referred to Girvanella, and its combination with what may be identified as Palaeonubecularia fluxa Reitlinger may be also classified in the form genus Osagia, an algal-foraminiferal symbiotic consortium.

Its "banded-cellular... plates and rounded bodies" are "widely distributed in the Triticites suite", in the eastern belt of shallow water banks, and in other areas, such as the Ishimbaevo massifs. The examples illustrated by Rauser-Chernousova (her Pl. 4, fig. 2 and 3) came from the Pseudofusulina horizon of Kinzebulatovo, and the Sarga horizon at Stolyarovka.

Other Blue-Green Algae. (See Plate 1, fig. 5, p. 78). Other Blue-Green algae, besides that indicated A, are also widely distributed in the form of various irregularly encrusting filaments over Mizzia-like bodies (Pl. 2, fig. 3, 4) or making small nodules by themselves (Pl. 2, fig. 5, and Pl. 5, fig. 2, 3).

Pseudovermiporella cf. sodalica Elliot. (Plate 1, figure 7.) One of the two examples of a "calcareous alga with septa" illustrated by Rauser-Chernousova resembles closely the recently described new genus and species of Permian alga Pseudovermiporella sodalica of the Middle East (Elliot, 1958, p. 419-422, pls. 1, 2). The right individual of Rauser-Chernousova's fig. 4 of Pl. 3 is particularly like Elliot's form, showing the same curved multi-layered cellular crust, apparently originally encrusted over a round unpreserved organic body. The left individual of fig. 4,

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pl. 3 is less regular and consists of slightly coarser cells of same kind, the size of the rows and the cells in them being close to that in Elliot's Pseudovermiporella.

Elliot provisionally considers Pseudo-vermiporella "a very primitive dasyclad alga, like Vermiporella" (p. 421), and this confirms Rauser-Chernousova's tentative classification of her similar fossil with algae.

Vermiporella. The alga Vermiporella was identified by Rauser-Chernousova in the shallow water organocenous-detrital limestones of the Lower Schwagerina zone, rich with "shamovells (= Tubiphytes Maslov) mizzias (siphonaceous algae), and vermiporells" (p. 43). The thick beds of these limestones "are particularly common in the southwestern extremity of the Eastern massifs." The limestones belong "in part to the second sub-facies ("b") of the facies of the submarine plateau," and their sections with algae are illustrated in fig. 1 and 5 of plate 2 (not reproduced here because a better illustration of Shamovella is reproduced in fig. 6, Plate 1. The other algae are well known).

Solenopora (?) cf. spongoides (Dyb). (See Plate 1, fig. 5, p. 78). Rauser-Chernousova questionably refers to Solenopora "large sheaf-like bodies (Pl. 3, fig. 6), apparently a kind of siphonaceous alga" (p. 76) in coarsely stratified to massif limestones of lower Sarga horizon in Stol-yarvo area. Her best illustration fig. 6, Pl. 3, (x20) shows sufficiently detailed structure typical of Solenopora, resembling that of Solenopora spongoides (Dybowsky) (see Maslov's 1956 illustrations Pl. 15 and 16); even the magnitude of cells of the Stolyarovka form is quite comparable to that in S. spongoides, but because of the great difference in age it seems likely to be a new species. A transverse section of it, not illustrated by Rauser-Chernousova, may furnish the specific differences from the Ordovician form.

Shamovella = Tubiphytes obscurus (Plate 1, fig. 6, p. 78). In the reviewed article there is only one new paleontologic name, Shamovella, which Rauser-Chernousova introduces in the footnote to page 17. It is an alga frequently referred to in her text as "wiggling white tubules of shamovella"

(p. 32), or simply as "shamovella" (in many pages).

She illustrated Shamovella in the half-tone photographs made for her thin sections, figs. 1 and 2 of her plate III, but gave it no specific name.

In a subsequently (1950) published book on the "Fossil calcareous algae of the USSR" Maslov points out that Rauser, Chernousova "gave the name Shamovella gen. nov." to one of the illustrated algal remains "without a description." By this statement he obviously meant that Rauser-Chernousova described her Shamovella only as a new genus, without giving it specific name, or indicating any previously described algal species as its genotype, and this makes her genus taxonomically invalid.

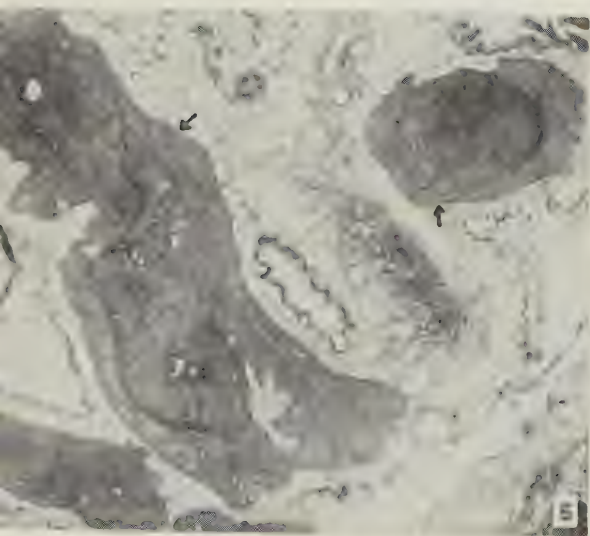
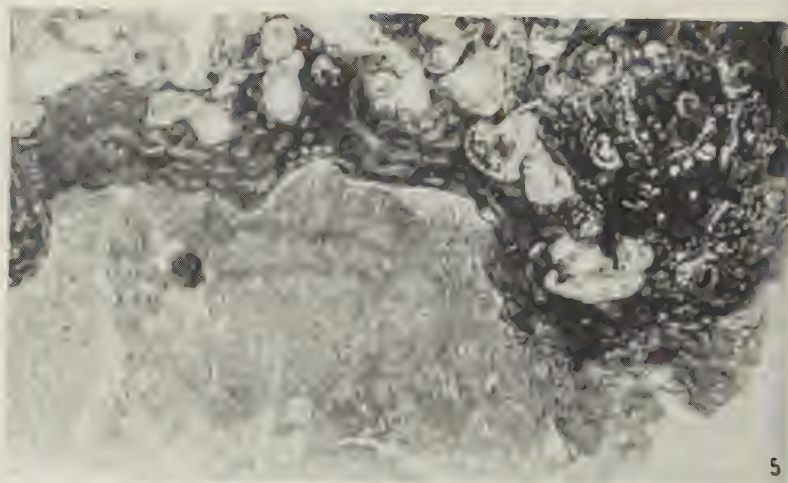
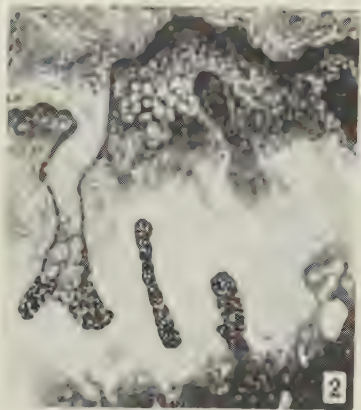
In his book, Maslov introduces a monotypic genus Tubiphytes, with T. obscurus new species as genotype. Without doubt this is exactly the alga names Shamovella by Rauser; the evidences for this conclusion are enumerated below. Shamovella Rauser-Chernousova is, therefore, a nomen imperfectus, and Maslov's Tubiphytes obscurus should be used in its place.

Systematic Description of Tubiphytes obscurus Maslov. 1950. Shamovella, Rauser-Chernousova, Truda Instituta Geologicheskikh Nauk, Akad. Sci. SSSR, vol. 119 (Geolog. Ser. No. 48), p. 17 (footnote), Pl. 3, figs. 1 and 2.

1956. Tubiphytes obscurus Maslov: Trudy Instituta Geologicheskikh Nauk, Akad. Sci. SSSR, vol. 160, p. 82-84, text-fig. 22; Pl. 25, fig. 1 and 3; Pl. 26; Pl. 27, fig. 1-3.

Maslov describes Tubiphytes obscurus as follows (1956, p. 82-83):

"Encrusting (epiphytic) organism, forming dark calcitic crusts around other organisms. Usually appears as irregularly wavy stick-like to worm-like cylinders, originating as a result of encrustation over some kind of evanescent stems, whose remnants remain in the form of tubes filled with secondary calcite. Layers of such overgrowths are variable in thickness, up to 1 mm. and more. The frequently observed growth bands are formed by dark aphanitic carbonate, almost non-translu-



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### EXPLANATION FOR PLATE 1.

FIGURES 1 to 4. Hydractinoids. Fig. 1 x10. Fig. 2 part of fig. 1, x20. Figs. 3,4. Vesicular tissue, x20. Sterlitamak horizon. Ishimbaevo area.

FIGURE 5. *Solenopora*? (below) with encrusting Blue-Green alga (above). Considered by reviewer to be *Solenopora* cf. *spongiodes* (Dyb.), encrusted by Blue-Green alga and aggregates of subcircular cells (with white interior) of *Palaeonubecularia flexa* Reitlinger. Sarga horizon. Stolyarovka.

FIGURE 6. *Shamovella* Rauser-Chernousova. "A multicellular coarse form." Considered by reviewer to be *Tubiphytes obscurus* Maslov. x10. Upper zone of Tastuba horizon. Ishimbaevo area.

FIGURE 7. "Calcareous alga with partitions." Considered by reviewer to be *Pseudovermiporella sodalica* Elliot. x30. Middle zone of Schwagerina horizon. Ishimbaevo area.

FIGURE 8. "Calcareous alga with partitions." Considered by reviewer to be *Ptychocladia* sp., n. sp.? x30. Middle zone of Schwagerina horizon. Ishimbaevo area.

scent in thin sections. When well preserved, the structure of the crusts appears heterogenous. Under intense illumination one can see a number of very thin (a few microns thick), entangled, dark filaments with no regularity in orientation. Within the crusts are frequently encountered fragments of various extraneous organisms (bryozoans, sponge spicules, foraminifers, etc.) and also the above-mentioned hollow tubes (possibly traces of calcareous alga), usually disposed along growth bands.

The discussed alga forms bioherms in the lower and upper-Artinsky deposits of the Permian in the ante-Urals (beginning with the *Schwagerina* horizon), and is an important rock builder. *Tubiphytes*-built limestones are frequently called by geologists "wormy" (*cherviakovye*), because of the abundance in them of the white, wavy, and branching cylinders of this alga, which are conspicuous against the gray background of the matrix. For some time I have called this organism *Tubiella*, just as it has been called so also by D.M. Rauser-Chernousova. However, I was compelled to abandon this name because under this same name has been described a living genus of Blue-Green algae."

Rauser-Chernousova describes her *Shamovella* thus (1950, p. 17, footnote 1):

"*Shamovella* gen. nov. is a name given to a calcareous alga in form of irregularly undulating tubes, with a lumen which possibly may be an evidence of its being an encrustation. Viewed externally the tubes are porcelain-white; in thin-sections they are dark-gray, fine grained, multi-banded (Pl. 3, fig. 1), or uniformly solid and with fine filamentous texture (Pl. 3, fig. 2).

The species of this genus are very diverse, and are widely encountered (in the limestones) from the Gjelian to Kungurian stages."

Elsewhere she states that (p.32):

"In a subfacies of submerged plateau, at the depths below 40-50 meters...where hydractinoids, bryozoans, and corals are very rare, shamovells are luxuriously developed, their wiggling white tubules occasionally overcrowding a rock, thus forming the so-called "cherviachnye" (wormy) limestones, or even lenses made of the turfs of these forms, with a beautiful encrusting structure."

Comparison of the illustrations of *Shamovella* by Rauser-Chernousova and of *Tubiphytes* by Maslov fully confirms their generic identity, those by Maslov being only slightly lighter gray, probably because of his sections being slightly thinner.

Alan Wood (1941) coined the informal term "algal dust" for a calcareous matrix precipitated by certain Lower Carboniferous algae, and consisting of "an extremely fine-grained aggregate of calcite crystals. On weathering this aggregate becomes minutely 'frosted' resulting in the well known porcelainous appearance of algal nodules" (1941, p.942). In observing the "algal dust" Wood finds "complete transition from algal nodules with strongly marked tubes (*Micheldeania gregaria* Nich.) through forms with looser tubes (*Ortonella furcata* Garw.) to those consisting of vague aggregations of tubes (some species of *Bevoastria*). The final stage is that of the *Spongiostroma* precipitate with no definite organic structure preserved. The different appearances depend on the type of alga making up the nodule, and on the rapidity of decay of the organic matter, but the association of algal dust with algal traces appears to be constant." (1941, p. 193).

The extremely fine-grained carbonate precipitate of *Shamovella* = *Tubiphytes* seems to be identical with the precipitate called "algal dust" by Wood, but apparently more than one kind of fossil algae was able to produce it.

#### Mizzia and Other Siphonaceous Algae.

Maslov (1956) disagrees with some identification of the algae illustrated by Rauser-Chernousova. He says that among her 15 photographs of algal remains, those identified as *Mizzia* "cannot be classified in this genus, but some can be referred to other siphonaceous green algae unrelated to *Mizzia*" (1956, p.21). Hence it would be safer to understand that whenever Rauser-Chernousova speaks about *Mizzia*, some kind of siphonaceous green alga is meant.

Foraminifera (Nubecularia and Palaeonubecularia) "Nubecularia"-like foraminifer and cellular loops of "Nubecularia" in quotation marks are mentioned by Rauser-Chernousova as rock builders in Sarga time, and she illustrates them in Pl. 4, fig. 3 associated with *Solenopora* sp.

Since the reviewed paper the "nubecularia"-like adnate aggregates of foraminiferal cells have been described by Reitlinger (1950) as *Paleonubecularia*, which is a reasonable differentiation of these widespread Carboniferous and Permian adnate aggregates from the original Tertiary foraminifer *Nubecularia*. The "nubecularia"-like forms mentioned by Rauser-Chernousova are identical with Reitlinger's *Paleonubecularia fluxa* from the Carboniferous and Permian of Russia.

#### Ptychocladia sp., n. sp. ? (Plate 1, fig.8)

The first of the two examples of "calcareous alga with septa" illustrated by Rauser-Chernousova, (Pl. 3, fig. 3) resembles *Chabokovia ramosa* Vologdin (1939, text-fig. 4 and Pl. 9, fig. 3; reillustrated by Elias, 1950, Pl. 43, fig. 16, 17), *Ptychocladia agellus* Ulrich and Bassler and its variety *P. agellus* var. *tenuis* (Elias, 1950, particularly Pl. 43, fig. 8., 10; and Pl. 44, fig. 3, 6, 7, 10), and *Bdelloidina*? *permica* Elias, 1950, Pl. 45, fig. 4). In shape, size and age Rauser-Chernousova's form is nearest to *Ptychocladia agellus* and its var. *tenuis* from the Upper Carboniferous of Nebraska, Kansas,

and Oklahoma, and differs from them seemingly only in lower and most crescent-shaped cells, which suggests that it is a new species of *Ptychocladia*, believed to be an adnate foraminifer (Elias, 1950, p.290-293).

Rauser-Chernousova's form came from Middle zone of Schwagerina horizon, Ishim-baevo area.

#### Hydractinoids. (See Plate 1, figs. 1-4, p.78)

Rauser-Chernousova mentioned and illustrated several forms of a very important reef building organism, previously called by her and her associates "hydroid" and "hydroidal corals" (in Trofimuk and Dubrovin, 1936, and Shamov, 1940). It seems that this is truly an undescribed hydractinoid unlike any known Paleozoic stromatoporoids, some of which were also reef builders, especially in Silurian time. It seems a privilege of Russian Paleontologists to describe and give name (names) to this most interesting reef builder. All of Rauser-Chernousova's illustrations of it are here reproduced. Her explanation for these is very brief. "Figures 1, 2, 4, 5. Hydractinoids, Ishimbai, Sterlitamak horizon. 1- x10; 2 - part of same. x20; 4, 5 -vesicular tissue. x20". There is only one paragraph in the text where some details in the occurrence of this fossil are mentioned (p.28): "In the excellent exposures of the massif hydractinoid limestones of Shak-Tau may be observed how the cups of hydractinoids and the spaces between them are filled by entirely unsorted crinoidal organogenous-detrital limestone with fusulines in inclined position. The prevailing disposition of them, however, approaches vertical, which indicates their falling from above and the immersion of the sharp point in a semi-liquid ooze."

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<u>specta</u> Raus.	70	<u>Schwagerina</u> <u>vulgaris</u> Scherb. 17	
<u>P. gregaria</u> Lee	39	<u>Septopora</u> <u>ovalis</u> Nov.	
<u>P. infecta</u> Viss.	60	<u>Septopora</u> <u>ovalis</u> var.	
<u>P. ishimbajeva</u> var. <u>correcta</u>		<u>atuberculata</u>	
Korzh.	53, 55, 56	<u>Septopora</u> <u>subinvisa</u> Sch.-Nest.	
<u>P. jaroslavlensis</u>	40, 57, 60	<u>Shamovella</u> Raus. (= <u>Tubiphytes</u>	
<u>P. jaroslavlensis</u> var.		<u>obscurus</u> Maslov)	17, 29, 32, 36, 39,
<u>fraudulenta</u> Kir.	59		40, 42-45, 47-49,
<u>P. krotovi</u> (Schellw.)	10, 17, 39, 41		65, 72, 73, 86-90,
<u>P. kutkanensis</u> Raus.	73		101
<u>P. longiarca</u>	61	<u>Siphonaceous</u> , algae	76, 88
<u>P. lutugina</u> (Schellw.)	20, 73	<u>Solenopora</u> ?	20
<u>P. lutuginiformis</u> Raus.	53, 55, 56	<u>Spiroplectammina</u> <u>bashkirica</u>	
<u>P. lutuginiformis</u> var.		Raus.	16, 36, 39, 41
<u>pointeli</u> Raus.	56, 57, 63	<u>Sponges</u> , spicules of	38, 40, 65, 69, 71,
<u>P. macarovi</u> Raus.	20		77-79, 85, 93, 94,
<u>P. mirabilis</u> Raus.	53, 55		98, 99
<u>P. moelleri</u> (Schellw.)	7, 18, 52-56, 58,	<u>Spores</u>	69, 77
	60, 62, 63, 83		
<u>P. moelleri</u> var. <u>aequalis</u>		<u>Tetrataxis</u> sp	36, 39, 70, 73
(Schellw.)	18, 56, 57, 63	<u>Tetrataxis</u> <u>irregularis</u> Mors.	18
<u>P. moelleri</u> forma <u>firma</u> Raus.	53, 54, 56	<u>Tetrataxis</u> <u>lata</u> Spand.	18
<u>P. ordinate</u> Kir.	67	<u>Thysanophyllum</u> <u>cystosum</u> Dobr.	18
<u>P. paraconfusa</u> Raus.	59, 63	<u>Tolypammina</u>	30, 32, 35, 36, 39,
<u>P. paragregaria</u> Raus.	16, 17		39, 40, 73, 75, 91
<u>P. paragregaria</u> var. <u>ascen-</u>		<u>Triticites</u> , diminutive species	16
<u>dens</u> Raus.	17	<u>Triticites</u> sp.	36, 85
<u>P. paraverneuili</u>	59	<u>Triticites</u> <u>acutus</u> Dunbar &	
<u>P. plicatissima</u> Raus.	19, 40, 66, 67	Condra	16
<u>P. pulchra</u> Kir.	59	<u>Triticites</u> <u>arcticus</u> (Schellw.)	16
<u>P. reticulata</u>	58, 59	<u>Triticites</u> <u>karlensis</u> Ros.	16
<u>P. rhomboides</u> Sham. &		<u>Triticites</u> <u>montiparus</u>	16
Scherb.	17	<u>Triticites</u> <u>paraarcticus</u> Raus.	16
<u>P. schellwieni</u> Viss.	20	<u>Triticites</u> <u>parvulus</u> (Schellw.)	16
<u>P. setum</u> Dunbar & Skinner	70	<u>Triticites</u> <u>primitivus</u> Ros.	16
<u>P. cf. solida</u> var. <u>allaguvatovi</u>		<u>Triticites</u> <u>shikhanensis</u> Ros.	16
Raus.	70	<u>Triticites</u> <u>simplex</u> (Schellw.)	16
<u>P. sulcata</u> Korzh.	18, 51-58, 62, 83	<u>Triticites</u> <u>stuckenbergi</u> Raus.	16
<u>P. sulcatiformis</u>	67	<u>Tschussovskenia</u> <u>capitosa</u> Dobr.	18
<u>P. uralica</u> (Krot.)	17, 18, 41, 56	<u>Tuberintina</u> sp.	36, 39
<u>P. urasbajevi</u> var. <u>speciosa</u>			
Raus.	73	<u>Vermiporella</u> , alga	43, 108
<u>P. urdalensis</u>	18, 59, 66, 67, 83		
<u>P. verneuili</u>	18, 19, 40, 59-61	<u>Wedekindellia</u> <u>uralica</u>	41, 42
	63, 66, 67		
<u>P. verneuili</u> var. <u>brevis</u> Raus.	60	Abbreviations of author's names in the in-	
<u>P. vissarionovae</u> Raus.	58, 59	dex and the text are as follows:	
<u>Pseudostaffella</u> cf. <u>ozawai</u>	41	Bel.	G.M. Belyaev
<u>Pseudostaffella</u> <u>sphaeroidea</u>	41	Cherd.	V.K. Cherdyntsev (Tcherdyntzev)
		Col.	M. Colani
<u>Quasifusulina</u>	39	Dobr.	T.A. Dobrolyubova
<u>Radiolaria</u>	38, 40, 42, 65, 69,	Dutk.	G.A. Dutkevich
	71, 77-79, 85,	Gors.	I.I. Gorsky
	93, 94, 98, 99	Keys.	A. Keyserling
<u>Radiolaria</u> , calcified	77	Kir.	G.D. Kireeva
<u>Rugosofusulina</u>	18, 19, 39, 41,	Korzh.	I.D. Korzhenevskii
	51-54	Krot.	P. Krotov
<u>Schubertella</u>	39	Lee	J. Lee
<u>Schwagerina</u> <u>constans</u> Scherb.	17	Lip.	O.A. Lipina
<u>Schwagerina</u> <u>fusiformis</u> Krot.	17	Maslov	V.P. Maslov
<u>Schwagerina</u> <u>princeps</u> Ehr.,		Mors.	V.G. Morosova (Morozova)
em. Moeller	4	Nik.	A.I. Nikiforova
		Nov.	E.I. Novikova

Putrja	F.S. Putrja
Ros.	S.E. Rosovskaya (Rozovskaya)
Schellw.	E. Schellwien
Scherb.	S.F. Scherbovich
Sch.-Nest.	M.I. Schulga (Shulga)-Nesterenko
Sham.	D.F. Shamov
Spand.	E. Spandel
Sul.	I.S. Suleimanov
Trisna	V.B. Trisna (Trizna)
Toula	Franz Toula
Vis.	A. Ya, Vissarionova
Wat.	J.A. Waters

Ronov, A.B., NOTES ON VOLUMETRIC STUDIES OF RUSSIAN PLATFORM SEDIMENTS AND HERCYNIAN VOLCANISM OF THE URALS. A review by George V. Chilingar.

# Hercynian Volcanism of the Urals during the Geosynclinal Subsidence, in the Light of Quantitative Relations (Ronov, 1946a).

There are two periods of volcanic activity in the history of geosynclines. The first one occurs during the "epoch of macro-oscillations," whereas the second is confined to the periods of downwarping of geosynclines (until the inversion of geotectonic conditions).

The quantitative study of the history of oscillating movements and volcanism of the Ural (Hercynian cycle) and the Great Caucasus (Alpine cycle) geosynclines, showed the existence of relationships between the absolute intensity of volcanism (second period), differentiation of effusive magma, and the rate of subsidence of the Earth's crust (Ronov, 1944.).

Further complete and thorough quantitative study of the oscillating movements and the Hercynian volcanism (Fig. 1) showed a definite relationship between the oscillating and volcanic processes in the Ural geosyncline.

A higher rate of downwarping of the geosyncline ( $\omega$ ) and a relatively slight manifestation of ascending movements (low value of the coefficient of elevation ( $\delta$ ), during the Middle Devonian and Lower Carboniferous time ( $D_2, C_1$ ), are synchronous with an increase in the absolute intensity of volcanism ( $J$ ) and intensification in the processes of differentiation (the high value

<sup>1</sup>Professor Ronov is considered one of the foremost experts on tectonics and volumetric studies of sediments in the USSR.

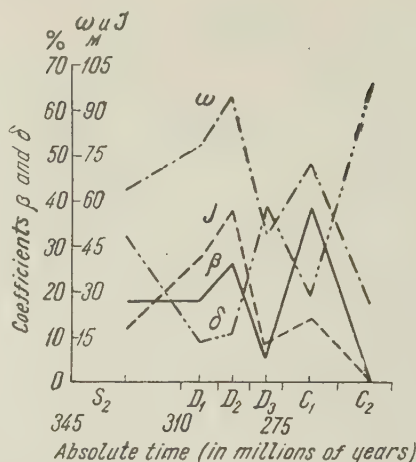


FIGURE 1. Quantitative relationship between the oscillatory movements and Hercynian volcanism of the Urals.  $\omega$ . Rate of subsidence of the Earth's crust in m per million years;  $J$ . Absolute intensity of volcanism in m per million years;  $\delta$ . Ratio of elevations to subsidences of the Earth's crust; and  $\beta$  is the  $S_3/S_4$  ratio, where  $S_3$  is the area of exposure of acid effusives and  $S_4$  is the exposure area of basic effusives. After Ronov, 1946a, p. 650.

of coefficient indicates an increase in the relative amount of acid effusives).

A decrease in the rate of downwarping ( $\omega$ ) of the Ural geosyncline during the Upper Devonian, with a simultaneous increase in the ascending movements (high value of the elevation coefficient  $\delta$ ), was accompanied by a reduction in the absolute intensity of volcanism ( $J$ ) and a lowering of the intensity of magmatic differentiation processes (low value of coefficient  $\beta$  indicates a reduction in the relative amount of acid effusives).

The end of surface volcanism in the Ural geosyncline, which occurred between the Lower and Middle Carboniferous, is closely correlated with the change in the oscillatory movements of the crust. At this time, an inversion of geotectonic conditions occurred in the Ural geosyncline. As shown by the quantitative tectonic curves (Fig. 1), the process of inversion was accompanied by a considerable reduction in the rate of downwarping of the geosyncline ( $\omega$ ), and a sharp increase in the ratio of elevations of subsidences of the Earth's crust ( $\delta$ ). At the same time, the magmatic activity changed its form of manifestation, and the surface effusions were superseded by deep-seated granite intrusions.

Figure 2 shows the changes in the mean

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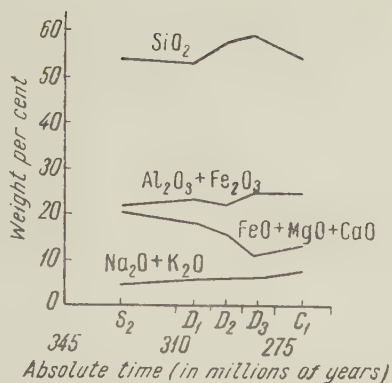


FIGURE 2. Variation of chemical composition of basic effusives of the Urals with time. After Ronov, 1946a, p. 650.

weight percentages of the principal oxides of basic effusives with time. It is based on some 200 chemical analyses of Middle Paleozoic effusives of the Urals, which were compiled by V.M. Sergievskiy. Sergievskiy also determined the geological age of the analyzed rocks. The curves plotted in Fig. 2 show that beginning with the Upper Silurian to the Upper Devonian the chemical compositions of the effusives remained within the range of variations of andesite-basalt type. During the Upper Devonian the average  $\text{SiO}_2$  content increased to such an extent that the basic effusives approached the average of an andesitic composition. Andesite-basalt type reappeared in the Lower Carboniferous. The Lower Carboniferous rocks, however, have a higher alkali content and considerably lesser amounts of RO oxides as compared to those of Upper Silurian. There is a general increase in the alkali content and  $\text{R}_2\text{O}:\text{RO}$  ratio with time. The amount of RO type oxides after reaching a minimum in the Upper Devonian, somewhat increases in the Lower Carboniferous. The basic Middle Paleozoic effusives are characterized by an increased  $\text{Na}_2\text{O}$  content.

As shown in Figure 3, the acid effusives are characterized by a wide range of differentiation. The Upper Silurian outflows belong to the dacitic varieties. The acid effusives then gradually undergo an evolution into a liparitic composition during Middle and Upper Devonian, going through the quartz albitophyres in Lower Devonian and become trachy-dacitic type in Lower Carboniferous. The examination of the  $\text{SiO}_2$  curve of Figure 3 reveals a distinct tendency towards a gradual increase in acid

properties, reaching a maximum in Upper Devonian and then somewhat decreasing in the Lower Carboniferous. The  $\text{R}_2\text{O}:\text{RO}$  ratio of acid effusives sharply increased with time. The relative amount of alkalis in the Upper Devonian is about four times that of the Upper Silurian. A certain reduction in their content, however, occurs in the Lower Carboniferous. The RO type oxide content shows a general decrease with time. The acid effusives of Middle Paleozoic are also characterized by an increased  $\text{Na}_2\text{O}$  content.

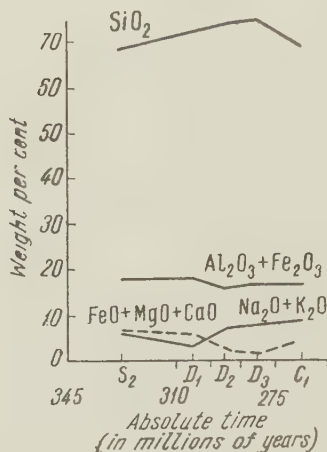


FIGURE 3. Variation in chemical composition of acid effusives of the Ural with time. After Ronov, 1946a, p. 651.

The similarity in the chemical evolution of acid and basic effusives points to their common origin from one parent magma. In calculating the chemical composition of the latter, one could not use an arithmetic mean because it would lead to large errors. Therefore, Ronov (1946, p. 651) introduced the correction coefficients  $\gamma = 1/\beta = S_1/S_2 \approx V_1/V_2$ , where  $S_1$  is the areas of surface exposures of basic volcanic rocks and  $S_2$  represents areas of surface exposures of acid rocks of the same age. Due to the folded nature of the Urals, the ratio of the areas corresponds approximately to the volumetric ratio  $V_1/V_2$ . Ronov calculated  $\gamma$  using a map of the Urals having a scale of 1:500,000. The percentage content of oxides in the parent magma ( $x$ ) was calculated by using the following formula:

$$x = \frac{(a\gamma) + b}{\gamma + 1} \%$$

where  $a$  is the weight per cent of the oxide in the basic effusives, and  $b$  is the weight per cent of the same oxide in the acid effusives.

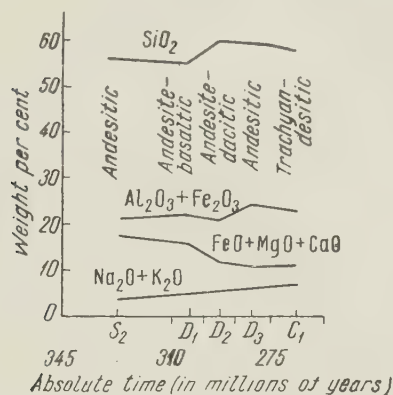


FIGURE 4. Evolution of the chemical composition of effusive magma of the Urals. After Ronov, 1946a, p. 651,

Figure 4, which is based on the above described calculations, shows the evolution in the chemical composition of effusive magma of the Urals. At the beginning of the Hercynian volcanic cycle ( $S_2$ ,  $D_1$ ) the parent magma is relatively poor in silica and alkalis. During the epoch of maximum rate of downwarping of the geosyncline (middle of the cycle,  $D_2$ ), when the ascending tendencies almost disappear (low value of  $\delta$ , Fig. 1), and  $SiO_2$  content reaches its maximum value and the relative and absolute quantity of alkalis increases. At the close of the volcanic cycle ( $D_2$ ,  $C_1$ ), there is a further enrichment of the magma in alkalis (the  $R_2O:RO$  ratio increases more than twice), whereas the acidity slightly decreases. As a result of the processes of differentiation, however, the acidity of the magma at the end of the cycle ( $C_1$ ) occupies a much higher level than at the beginning ( $S_2$ ). Thus the general trend of magma evolution during Hercynian time was oriented towards an increase in acidity and alkalinity.

Regions of Deposition and Erosion of Russian Platform of Hercynian and Alpine Age (Ronov, 1946b and 1949). Measurements of the areas of deposition and erosion of the Russian Platform of Hercynian and Alpine ages are considered in these papers.

The total area of the regions of deposition and erosion, covered by measurements, was 3,700,000 km<sup>2</sup> for the Hercynian cycle and 5,100,000 km<sup>2</sup> for the Alpine cycle. Ronov used V.V. Belousov's maps in addition to his own. For Hercynian cycle, the measurements were carried out within the territory bounded on the north by the Arctic Ocean, on the south by the Donetsk geosyncline, on the south-east by latitude 50°N, and on the east by the boundary of the Ural geosyncline and the Platform (Fig. 5).

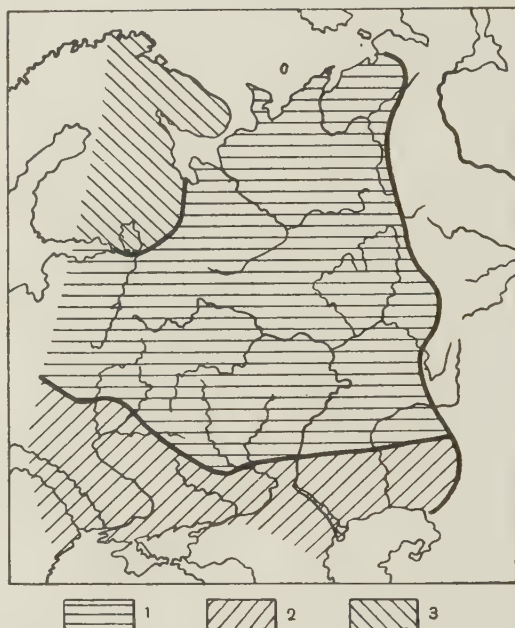


FIGURE 5. Map showing the measured areas of Hercynian (1 and 3) and Alpine (1, 2, and 3) Russian platform. After Ronov, 1949, p. 206.

A considerably greater area has been studied for the Alpine cycle, because of Platform conditions in the area of the former Donetsk geosyncline. The southern extremity of the Volga-Pechora subgeosyncline and the Ural-Emba region were also included in the study. This additional area is represented in Figure 5 by the shading inclined to the left.

Table I shows, in a stratigraphic sequence, the variation in areas of deposition and erosion from one epoch to another. The areas of sedimentation, expressed in per cent of total areas, were then plotted versus the absolute time in millions of years (Fig. 6.) This figure distinctly delineates two great cycles of variation, namely Hercynian and Alpine. Each of these cycles began at a time when, as a

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TABLE 1 - Areas of deposition and erosion of Russian Platform during Hercynian and Alpine cycles (after Ronov, 1946b, p. 828).

Cycle	Epoch (age)	Areas in thousands of km <sup>2</sup>			
		Regions of accumulation	Regions of erosion	Total	Areas of accumulation
Hercynian	Eifel stage (D <sub>2</sub> <sup>1</sup> )	0	3750	3750	0
	Givetian stage (D <sub>2</sub> <sup>2</sup> )	2030	1670	3790	55*
	Upper Devonian (D <sub>3</sub> )	3320	400	3720	89*
	Tournaisian age (C <sub>1</sub> <sup>t</sup> )	1670	2030	3700	45
	Viséan age (C <sub>1</sub> <sup>v</sup> )	2720	980	3700	43
	Middle Carboniferous (C <sub>2</sub> )	2750	930	3680	75
	Upper Carboniferous (C <sub>3</sub> )	2200	1520	3720	59
	Artinskian age (P <sub>1</sub> <sup>a</sup> )	1310	2390	3700	35
	Kungurian age (P <sub>1</sub> <sup>k</sup> )	1290	2410	3700	35
	Kazanian age (P <sub>2</sub> <sup>kaz</sup> )	1090	2610	3700	29
	Tatarian age (P <sub>2</sub> <sup>tat</sup> T <sub>1</sub> )	1290	2540	3830	34*
Alpine	Middle and Upper Triassic (T <sub>2-3</sub> )	0	3810	3810	0
	Lower Jurassic (J <sub>1</sub> )	560	4560	5120	11
	Middle Jurassic (J <sub>2</sub> )	810	4300	5110	16
	Upper Jurassic (J <sub>3</sub> )	2950	2140	5090	58
	Lower Cretaceous (Cr <sub>1</sub> )	2280	2820	5100	45
	Upper Cretaceous (Cr <sub>2</sub> )	2590	2560	5150	50
	Paleogene (Pg)	1790	3350	5140	35
	Miocene (Ng <sub>1</sub> )	640	4500	5140	12
	Pliocene (Ng <sub>2</sub> )	590	4520	5110	11
	Recent epoch (Q)	0	5120	5120	0

\* These values have been revised to 73, 82, and 38, respectively, in Ronov's more recent work (1949, p.209).

result of general elevation, the Russian Platform became a vast and continuous region of erosion (end of D<sub>2</sub><sup>1</sup> and end of T<sub>3</sub>). Then the curve records the expansion of the regions of accumulation, reaching a maximum in D<sub>3</sub> and J<sub>3</sub>, respectively.

Subsequently, there is a gradual reduction in the regions of accumulation and a corresponding expansion of the zones of erosion with time. As a result, a general rise of the Platform occurred at the close of the cycles (T<sub>2</sub> for Hercynian, and Q for

Alpine).

Although there is a complete qualitative similarity in the sequence of the processes, one could also observe quantitative points of distinction between the two cycles: (1) the maximum expansion of the deposition areas during the Hercynian cycle (in the Upper Devonian) reached about 90% of the total area, whereas (2) the Alpine maximum ( $J_3$ ) constituted only 60% of the total area. In addition, the maximum development of the regions of accumulation during the Hercynian cycle was attained twice as rapidly as that of the Alpine cycle.

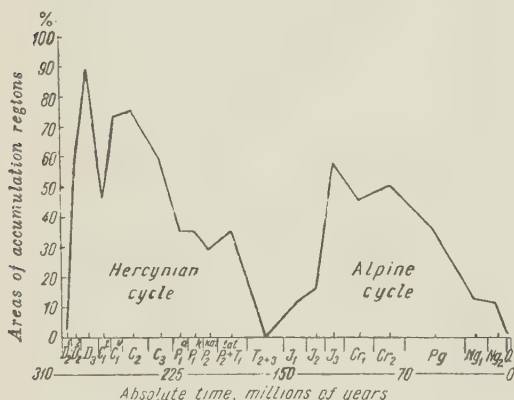


FIGURE 6. Variation of sedimentation areas (expressed in % of total area) of Hercynian and Alpine Russian platform with time. After Ronov, 1946b, p. 829.

The curve of Figure 6 shows two maxima ( $D_3$  and  $C_1^V - C_2$ ) and a minimum ( $C_1^I$ ) between them in the Hercynian cycle, and similar two maxima ( $J_3$  and  $Cr_2$ ) and a minimum ( $Cr_1$ ) in the Alpine cycle. From the Artinskian ( $P_1^a$ ) to the Tatarian ( $P_2^{tat}$ ) age the curve exhibits a nearly horizontal portion, before and after which it is steeply inclined. A similar terrace is observed in the Neogene.

The similarity in the configuration of the Hercynian and Alpine portions of the curve shows that the processes of redistribution of the regions of accumulation and erosion followed the same periodic law in the two cycles.

If the regions of accumulation of the Russian Platform represented only the marine sedimentary rocks, then Figure 6 would also reflect the history of transgressions and regressions. This is not the

case, however, because of the wide distribution of continental facies over the Russian Platform - 25% of the total sedimentary deposits in the Hercynian cycle, and 10% in the Alpine cycle.

**Quantitative Study of the History of Oscillatory Movements of the Russian Platform** (Ronov, 1946c) The epeirogenic movements of the Hercynian and Alpine Russian Platform have been studied quantitatively by measuring the volumes of sedimentary rocks. The paleoisopach and paleofacies maps used in this study were compiled by V.V. Belousov and Ronov. About sixty of these maps have been translated by the reviewer. More than 3,000 measurements have been made of areas and volumes occupied by sedimentary rocks of various facies of Paleozoic, Mesozoic, and Cenozoic ages. Figure 7 shows the area studied and the approximate tectonic framework of the Hercynian Russian Platform.

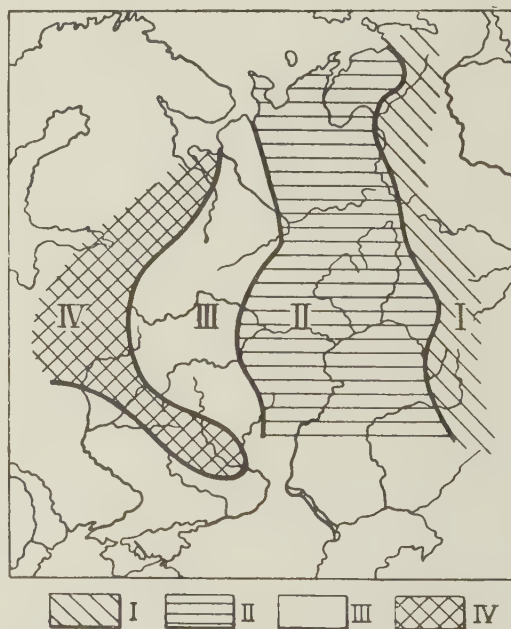


FIGURE 7. Map showing the areas studied volumetrically, and the approximate tectonic framework of the Hercynian Russian platform. I. Ural geosyncline; II. Volga subgeosyncline; III. Moscow subgeosyncline; and IV. eastern wing of Western subgeanticline and Vornonezh subgeanticline. After Ronov, 1949, p. 207.

The accuracy of Ronov's volumetric measurements of sediments of Russian Platform does not exceed  $\pm 8\%$ . Because of folding the volumes measured in the geosynclinal zones are on the low side,

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resulting in even lower accuracy.

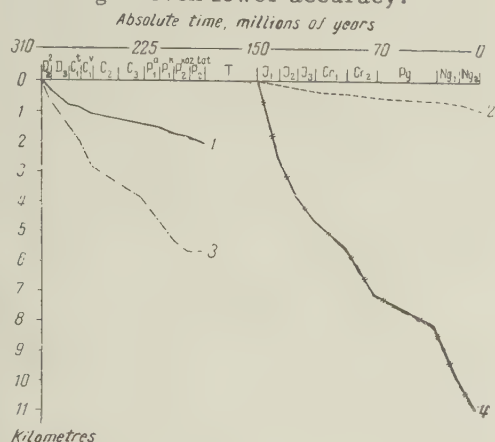


FIGURE 8. Average amount of downwarping (in km) of (1) Hercynian Russian platform, (2) Alpine Russian platform, (3) Hercynian geosyncline of the Urals, and (4) Great Caucasus Alpine geosyncline. After Ronov, 1946c, p. 161.

Figure 8 shows the average subsidence of (1) Hercynian of the Russian Platform, (2) Alpine of the Russian Platform, (3) Hercynian geosyncline of the Urals, and (4) Alpine geosyncline of the Great Caucasus. The examination of figure 8 reveals that the maximum subsidence of the Russian Platform occurred during the Hercynian cycle (2 km). It is 2.5 times greater than the maximum subsidence of the Alpine Platform (0.8 km). On comparing these values with the decidedly underestimated figures for the Great Caucasus and Ural geosynclines, one can observe that the maximum average subsidence of the latter (5.7 km) is at least three times as great as that of the Platform of the same age; and in the case of Alpine Great Caucasus geosyncline the subsidence of 11 km is 14 times as great as that of the platform of the same age.

Figure 9 shows the average rate of subsidence of the Russian Platform. The rate of subsidence was high at the beginning of the Hercynian cycle ( $D_2^2$ ). Subsequently it decreased at first very rapidly and then very slowly during the second half of the Hercynian and the entire Alpine cycle. Two maxima of subsidence rates are well pronounced at the beginning and at the end of each cycle.

Figure 10 shows the average rate of subsidence of the Russian Platform as compared to that of the Ural and Great

Caucasus geosynclines, and reveals a certain parallelism between the movements. The amplitude of oscillations, however, are considerably less on the Hercynian and Alpine Platforms (especially the latter). The downward and upward movements on the Russian Platform somewhat lagged behind the movements of the adjacent geosynclines of the same age.

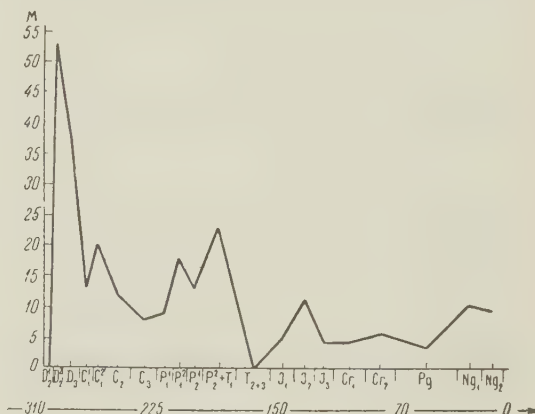


FIGURE 9. Average rate of subsidence of the Hercynian and Alpine Russian platform (in m per million years). After Ronov, 1949, p. 232.

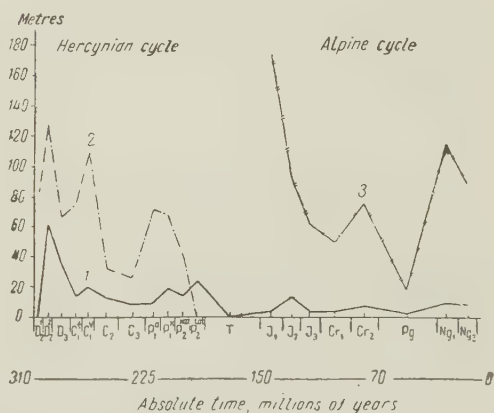


FIGURE 10. Average rate of subsidence of (1) Russian platform as compared to that of (2) Ural geosyncline and (3) Great Caucasus geosyncline, in m per million years. After Ronov, 1946c, p. 163.

Thus Figures 9 and 10 reveal a well pronounced periodicity and synchronous nature of the movements of the Platform and in the adjacent geosynclines of the same age. The cycles of oscillations develop in a geosynclines of the same age. The cycles of oscillations develop in a parallel way, but the movements on the

Platform lag behind those of the geosynclines. The movements on the platform, however, go on after the adjacent geosynclines have completed their development.

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## THE STUDY OF HYDROLOGY IN EASTERN EUROPE. A review by Steponas Kolupaila<sup>1</sup>

Research in hydrology in the Western Hemisphere is now overshadowed by nuclear engineering and space science. Water, however, remains an important factor for life on this Earth, for as long as we are bound to our planet. It is significant that hydrology is not so neglected in Eastern Europe, particularly behind the Iron Curtain.

The USSR presented to the XI General Assembly of IUGG, Association of Scientific Hydrology, in Toronto, 1957, a communication of the scientific work done in hydrology in Russia. A large number (close to 100) institutions employed in research on

continental hydrology are listed. The State Hydrologic Institute, established in 1918 by the eminent Russian hydrologist, Professor V.G. Glushkov, is perhaps the most important. A list of recent publications, including 552 books and articles, concludes the communication. The present review is limited to the most important works among those available to the reviewer.

## Publications of the State Hydrologic Institute

The Institute publishes series of papers, called *Izvestia*, *Zapiski*, and *Trudy*, each more than 120 volumes.

Several volumes of *Trudy* are issued every year. Each volume is dedicated to a particular problem and contains articles by different authors and is well edited and illustrated. The following volumes were published in 1957:

Volume 59, 223 pages, six articles. Experimental investigations of water balance elements in the Valdai Region (hill country dividing the Volga Basin from the Neva and Daugava Basins). An experimental station was in action in this area from 1951 to 1955. Subjects include: Evaporation in forest and in meadow, snow reserves estimation, melting processes, and spring flow formation.

Volume 60, 106 pages, six articles. These include subjects such as swamp hydrology, evaporation studies, influence of drainage, hydrophysics, conditions of peat mining and turf drying.

Volume 61, 307 pages, eleven articles. This volume is dedicated to problems of runoff formation and methods of design. The articles cover unit diagrams, runoff variations during seasons and months, genetic runoff formula, statistical computations, influence of human culture, ground water significance for temporary creeks, runoff diagrams for flat lands, average flow in small rivers of steppes, etc.

Volume 64, 58 pages, eight articles. Hydrometric instrumentation is reported on. The subject include: component runner for current meter, calibration and performance of current meters in use,

<sup>1</sup>Department of Civil Engineering, University of Notre Dame, Indiana.

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transmission of stage observations, and recording gages.

Volume 66, 140 pages, five articles. This volume deals with problems of lake and reservoir investigations. Wind action on levels, wage investigation, ice troubles in reservoirs, ice regime observation from airplanes are reported on.

Several more volumes appeared on other problems.

### Publications of the Central Institute of Forecasts

Valuable hydrologic studies are being published by this institution in its Trudy Tsentralnogo Instituta Prognozov. In 1957 there appeared:

Volume 50, 168 pages, seven articles. This volume deals with problems of forecasts for spring and summer runoff; snow-melt floods, storm-rain floods, design of diagram of spring flood wave, methods of forecasts for several rivers and reservoirs summer flow forecasts, long-term forecasts of low water.

Volume 51, 150 pages, six papers. Long-term forecasts are dealt with, and include atmospheric rhythms and their correlation with the sun, synoptic conditions for unusually cold weather waves in various regions, rhythms of ultrapolar processes.

Volume 54, 97 pages, four articles. The major subject is runoff formation from melting snow. Permeability of frozen soil, snow cover dynamics, water yield during melting, particular conditions of spring runoff formation in the northern part of European USSR are reported on.

An important systematic treatise on forecasts was published in 1957: E.G. Popov, Hydrological forecasts, 460 pages. It is a textbook for a course taught in special hydrometeorological schools for twenty years.

### Monographs

All current publications on stages and discharges of Russian rivers are secret.

Stage observations are published in volumes "Svedeniia ob urovne vody," discharges in series "Rezhim rek," recently in "Gidrologicheskie svedeniia po rekam i ozeram." Sometimes runoff data are summarized in synthetic works, e.g.:

B.D. Zaikov, Average runoff and its distribution during a year in the USSR territory, 1946.

Very short hydrologic characteristics of Russian rivers were given in fifty volumes of the Large Soviet Encyclopedia, 1949-1958. There is one synthetic work:

L.K. Davydov, Hydrography of the USSR Volume I, "General characteristics," 1953, 184 pages; Volume II, "Regional hydrography," 1955, 600 pages, for fifteen regions, mostly limited to river basins. General data are given, rivers and important tributaries are described, their runoff, water regime, ice events, silt transport, water quality mentioned and lakes and swamps are also reported on. This work is of particular interest to geography and regional hydrology.

Two monographs on particular hydrologic subjects were published recently by the State Oceanographic Institute, dealing with the mouths of important rivers:

S. S. Baidin, F.N. Linberg, and I.V. Samoilov, Hydrology of the Delta of the Volga River, 1956, 331 pages.

M.M. Rogov, Hydrology of the Delta of Amu-Daria River, 1957, 254 pages.

Both books are on a high scientific level. They contain detailed characteristics of levels, water discharges, silt transportation, chemistry, ice processes, changes of bed and economical aspects. They are of great importance, particularly in connection with the continuing unusual drop of the Caspian Sea water level (six feet between 1930 and 1947), which severely endangers the entire economy of that region. A special report of the Academy of Sciences of USSR, "Super-long-term forecasts for the level of the Caspian Sea," 1957, 67 pages, is concerned with this vital problem. In eight articles, Russian hydrologists try to show that construction of great dams along the Volga River will permit better

regulation of runoff and relieve the Caspian situation, although the reviewer is of the opposite opinion.

A systematic treatise on river mouths, unique in this field is I.V. Samoilov, Mouths of rivers, published in 1952, 526 pages. It deals with the rivers of the world.

#### Other Publications

The Institute of Hydrometeorological Instrumentation publishes its own Trudy, Volume 5, 156 pages, which was issued in 1957. It contains new developments of meteorological and hydrological devices.

The Hydrometeorologic Research Institute of Kazakhstan published Volume 9 of its Trudy, 102 pages, in 1957, with eight papers on particular hydrologic conditions of Kazakhstan (Central Asia): methods of runoff forecasts, determination of maximum runoff, mud torrents investigations, temporary rivers, mountain rivers, regime of rivers in Western Kazakhstan.

The Arctic Research Institute dedicated Volume 208 of its Trudy to the hydrology of rivers of the Soviet Arctic, 1957.

Academy of Sciences of Armenia published a book by A.N. Vazhnov of mean annual runoff of rivers of Armenian SSR and its distribution during the year, 1956, 155 pages.

Studies of hydrologists of Lithuania are published in series of the Academy of Sciences of Lithuanian SSR: "Geologijos ir Geografijos instituto Moksliniai pranesimai," "Melioracijos instituto Darbai," "Geografinis Metrastis," and also in "Kauno Politechnikos Instituto Darbai."

The Russian systematic literature on hydrologic problems is also very extensive. Besides textbooks in hydrology by Oppokov, Ohievskii, Velikanov, Chebotarev, the following valuable books should be mentioned:

D.L. Sokolovskii, River runoff, 1952, 491 pages; A.A. Luchseva, Practical hydrology, 1950, 291 pages; S.N. Nikitin, Fundamentals of engineering hydrology, 1952, 231 pages; G.V. Lopatin, Silt in rivers of USSR, 1952, 367 pages; A.I. Chekrenev, Water ways, Volume 1, 1953,

511 pages; N.A. Domanevskii, Investigations and explorations of rivers and lakes, 1953, 363 pages; E.V. Boldakov and O.V. Andreiev, Stream crossings, 1956, 405 pages; A.I. Chebotarev and K.P. Klibashev, Hydrologic computations, 1956, 296 pages; V.I. Shvets, Investigations in hydraulic engineering, 1956, 168 pages; E.V. Blizniak, Investigations in hydraulic engineering, 1956, 268 pages; E.V. Blizniak, E.F. Belikov and L.D. Belyi, Water power investigations, 1957, 320 pages. I.V. Bogoliubova, Mud torrents, 1957, 152 pages.

Water measurements - hydrometry - are represented by a number of text-books. The more instructive are: V.D. Bykov, Hydrometry, 1948; V.V. Lebedev, Hydrology and hydrometry in problems, 1952; M.L. Leivikov, Meteorology, hydrology and hydrometry, 1949 and 1955; A.A. Luchsheva, Practical hydrometry, 1954; N.A. Solomentsev, Hydrometry, 1950 and 1957.

Some special hydrometric features are reported on in: V.V. Aristovskii, Hydrometric structures and equipment, 1949, 298 pages; V.N. Iartsev, Maintenance hydrometry, 1951, 279 pages; G.V. Zhelezniakov, Hydraulic backgrounds of methods of river hydrology, 1950, 163 pages; V.I. Chebotarev and A.R. Skue, Hydrometric structures, 1954, 371 pages.

And one significant book, unique in the world literature: N.M. Shchapov, Hydrometry of hydraulic structures and machinery, 1957, 237 pages. It deals with water measurements of spillways, in penstocks and intakes of power plants.

Several popular books on hydrologic subjects are of interest: I.V. Popov, Life of river channels, 1955, 98 pages; E.V. Boldakov, Life of rivers, 1953, 63 pages; R.A. Nezhikhovskii, Neva River, 1955, 94 pages; B.A. Apollov, Caspian Sea and its basin, 1956, 118 pages; S.V. Lutkovskii, Ice formation on lakes, rivers and seas, 1957, 119 pages; A.I. Duvanin, Sea level, 1956, 59 pages; N.N. Romanychev, Tides in the sea, 1955, 44 pages.

The hydrologic literature in the USSR demonstrates enormous growth of this science, and Russian hydrologists can be commended for their great successes.

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The reviewer feels entitled to make this statement, because in 1918, at the beginning of his career, he published Hydrometry, the first textbook in the Russian language, and in 1921 the first index of hydrometric literature.

### Poland

Prewar Poland had its Hydrographic Institute, which published the Hydrographic Annuals. A three-volume treatise of hydrology was published by K. Pomianowski, M. Rybciński, and K. Wóycicki in 1933-1939; the fourth volume was added in 1947.

Contemporary Poland has the Hydrological and Meteorological Institute, which issues the scientific publications Wiadomości and Prace. Textbooks published include: K. Debski, Hydrologic I hydraulika, 1943, 390 pages; K. Debski, Hydrologia Kontynentalna, I. Hydrometria, 1955, 403 pages; Polish hydrologists have several periodicals in which to publish, such as Przegląd Geofizyczny, Acta Geophysica Polonica, Gospodarka Wodna. Professor A. T. Troskołanski dedicated the third volume of his Hydromechanika Techniczna to hydrometry, Pomiary wodne, 1957, 24+662 pages, with a multilingual dictionary.

### Czechoslovakia

A comprehensive book in the Slovak language was published in 1957: O. Dub, Hydroológia, hydrografia, hydrometria. Bratislava, 485 pages.

### Hungary

Hungary instituted hydrological research with an eminent hydraulic engineer P. Vásárhelyi. The first European textbook on this subject was published in the Hungarian language:

S. Hajós, Hidrometria, Budapest 1906, 320 pages.

The Research Institute for Water Resources continues to publish its excellent quarterly "Vízügyi Közlemények" (Hydraulic Engineering) under editor W. Lászlóffy, widely known hydrologist. Every year the Institute issues its annual report "Beszámoló" with series of valuable contributions to the science of hydrology. The

Institute also continues to publish its annuals "Vízrajzi Évkönyv" with data of stage and discharge observations. In 1958 Volume 61, 282 pages, 1956 was issued.

Hungary has published an extensive handbook: E. Németh, Hidrológia és Hidrometria, Budapest 1954, 662 pages plus tables.

The progress of hydrology in Hungary was presented to the Toronto Assembly in a report by E. Németh, "Hydrological Research in Hungary," 1957.

### Yugoslavia

The Hydraulic Engineering Institute "Jaroslav Černi" is publishing a trilogy by V. M. Jevđević, "Hidrologija." The first volume, Beograd 1956, 401 pages, contains general hydrology and mathematical methods (in the Serbo-Croatian language). Among other publications of the Institute is one of particular interest: S. Jovanović, "Current meter", 1957, 106 pages.

### Bulgaria and Rumania

The reviewer has had no opportunity to see hydrologic literature of Bulgaria or Rumania.

I. Marinov, Director of the Research Institute of Hydrology and Meteorology in Sofia wrote recently an article on hydrology and water development schemes in Bulgaria (Water and Water Engineering, 62, 1958, no. 753, pages 447-482, London). According to that paper Bulgaria has a Hydrometeorological Service, reorganized in 1949, and operates 296 gaging stations. A summary of observations was published in the Hydrological Reference Book of Bulgarian Rivers, in two volumes.

Rumania has published since 1956 its periodical "Meteorologia si Hidrologia," which presents papers on hydrologic research, e.g. "Hydrological balance in Romania", by D. Lăzărescu and I. Panait, in the issue no. 4-6, October through December, 1957.

### Suggestions

The reviewer hopes that American hydrologists will show more interest in the

work done so efficiently in other countries. We will be surprised to find that many methods applied there are of American origin. We should be proud of how far our pupils have outdistanced their teachers!

It would be wise to translate valuable books or series of articles for those who cannot read the languages of Eastern Europe. Hydrology is important for human life and prosperity; therefore it should not be secondary to other important sciences.

Scheidegger, A. E. PRINCIPLES OF GEODYNAMICS.<sup>1</sup> A Review by V. V. Belousov. Translated by Arthur N. Rohl.

Although the author of this book, A. E. Scheidegger, displays a thorough knowledge of both mathematics and geophysics, his training in geology has at best been deficient. Despite these odds, he has set himself the task here, of considering questions of the development of the earth's crust - questions which are basically geological.

The author must be commended for his frank confession to a lack of authority and reliable judgment in the area of geodynamics. He states, in the introduction, that the book represents rather, a compilation of different ideas and points of view.

The first chapter is devoted to an account of geological information. Among the topics discussed are rocks and geologic time, paleoclimatology (which the author considers from the viewpoint of polar migration), the geometry of continents, the structure of folded areas, and the elementary structural forms - folds and faults. Unfortunately, from the viewpoint of clarity, the author's method of exposition leaves something to be desired. His discussions are sketchy and biased.

The second chapter contains a brief, but learned account on geophysical data - an area well within Dr. Scheidegger's scope.

In the third chapter, the mechanics of deformation are examined. This account is highly mathematical; unfortunately, it

does not include the material on geodynamics which the author deals with in a later chapter. He confines himself rather, to a discussion of the theories of elasticity and plasticity without, furthermore, examining the part of the theory relevant to geology. In the last section of the chapter, although the author speaks about the state of matter in the earth's interior, the elementary information he gives is interwoven with speculations which are meaningful only if a whole series of unproved approximations suddenly become justified. This is the typical approach of a mathematician who does not understand the peculiarities of natural sciences. This, in fact, can be said to be the major fault of Dr. Scheidegger's book: primarily a mathematician and geo-physicist, he treats geological subjects from a mathematician's point of view. His chapter on "Effects of the Earth's Rotation" illustrates this tendency. His consideration of whether or not the poles have migrated is determined not by an analysis of historical geological data, but on mathematical considerations based on an opinion of the viscosity of the earth's crust.

Chapters five and six bear out this approach. In chapter five, the author's discussion of the origin of the earth does not include the most recent hypothesis on the accumulation of the earth from a swarm of cold particles; neither are his theories on the history of continents and oceans supported by geological information. Chapter six, entitled "Orogenesis", contains none of the established geological (geotectonic) laws of the structure and development of folded zones. The hypotheses which are given are treated only to a mathematical analysis, not a geological one.

In his last chapter, the author discusses in greater detail the subjects which comprised the conclusion of his first chapter, among which were domes, volcanoes, and meteor craters. Perhaps the most unfortunate part about this chapter is the author's lack of differentiation between the two types of domes - the diapir kind, and the ordinary uplifts so extensive in Platform areas, and well-known in North America for their great reserves of petroleum.

It must be said in conclusion that Dr. Scheidegger is an extraordinarily able specialist within his own area of investigation.

<sup>1</sup>Springer-Verlag, Berlin-Göttingen, Heidelberg 1958.

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For this reason, his literary venture into the science of geology is regrettable. Although, as was previously stated, his mathematical analyses are astute, they have little to do with actual geology. Obviously, a competent geologist must be able to use mathematics as a tool. And

any geologist who possessed Dr. Scheidegger's assets in this field is indeed fortunate; however, before he essays another work on the nature of the earth, Dr. Scheidegger might well avail himself of more study in the science and methods which he seeks to demonstrate to others.

# *Notes on international scientific meetings*

## THE FOURTH CARBONIFEROUS CONFERENCE

Heerlen, Netherlands, September 1958

by Max K. Elias

The center of the coal mining district of Netherlands, Heerlen, is what Germans call "gemütlich", a town of some 20,000 people, with crooked streets and the excellent "Grand Hotel", even if without private baths in the rooms. But what food, and what service! But on with the report.

After registering at the Bureau of Mines, where the cordial personnel made you feel at home you walked the few blocks to the City Hall, where all the meetings were held. Two rows of poles with large flags of all participating nations rose midst huge vases of flowers on either side of a wide entrance and from a spacious two-story hall, a street-wide black marble stairway led to the window side of the balcony where luxurious easy chairs and low tables invited us for chats with old and newly acquired friends. The other three sides of the balcony were furnished with long tables on which were displayed the latest books and periodicals, mostly pertaining to the Carboniferous formations of the world. On the adjacent walls were geologic maps and sections, some of which were shown and explained at the subsequent sessions of the Congress. One of the three sides was wholly occupied by the books and maps from Soviet Russia; the display being in charge of the quiet, cordial Professor V. S. Yablokov of Leningrad. French, British, German, Polish, Yugoslav, and other publications and maps were equally impressive, showing much progress in detailing of the Carboniferous of Europe and other parts of the world. The Dutch too, could be justly proud of their excellently produced reports, a testimony to their own progress in the study of the Carboniferous and other rocks of their own and other countries of the world. Their own coal industry is now augmented in an important way by home-produced oil, which currently supplies about 30 percent of the domestic demand. Oil derricks are rapidly becoming a part of the landscape, com-

peting with the old graceful Dutch windmills.

Dr. A. A. Thiadens, the new Director of the Bureau, assumed the presidency of the Congress, left vacant by the death of Professor Jongmans, the originator of the Congress; Dr. S. van der Heide continued as the secretary.

The three American delegates, Harold Fisk, D. S. Potter and Max K. Elias, were badly outnumbered by more than a score of delegates each from Germany, France, Great Britain, Soviet Russia, and the Netherlands itself, with the delegates from Belgium close behind. The American delegates were nevertheless given a prominent part in the program. Dr. Harold Fisk of Houston spoke on the Mississippi delta and Dr. P. S. Potter of the Illinois Geological Survey about the river systems in the late Mississippian and early Pennsylvanian of Illinois. The writer attempted to summarize the data on the paleontologic control over the boundaries of the Carboniferous and its major subdivisions in America, Western Europe, and Eastern Europe. Our lantern slides were highly praised by the audience. One of the Russian delegates mentioned that they need not understand Fisk's English as the illustrations told them the whole story without words, particularly because in many respects the delta is much like that of the Volga and other major rivers of Russia.

Dr. M. Rutten of Holland captivated the delegates with a lucid discussion of the major problems that confront us all when we attempt to correlate major orogenies and unconformities of the world.

It would be difficult in the brief space of this review to do justice to the numerous interesting oral presentations (and to those papers which were distributed at the Congress in typed form by the authors ad absentia). Being busy examining the displayed literature and in personal con-

<sup>1</sup>Professor Emeritus, University of Nebraska.

## INTERNATIONAL MEETING NOTES

tact with the delegates, particularly those who came from Russia, the writer missed some papers, particularly those of the sessions held simultaneously in different halls for lack of sufficient time. Because the active participants had been requested to bring to the Congress complete texts and illustrations of their respective papers (and which was nearly universally obeyed), their publication in the "Compte Rendu of the 4th Congress", will not be much delayed.

Since no delegates from the Soviet Russia attended the 3rd Carboniferous Congress in 1952, their large delegation of 23 at the 4th Congress, 14 of whom were women, attracted much attention. The rest of this report will be mostly about them.

The Russians' oral and written presentations at the Congress were mostly in English, but one was in German. Thus it happened that the only Russian heard at the official sessions of the 4th Congress at Heerlen was by the writer, who read his paper both in English and Russian, paragraph by paragraph. Subsequently, Professor N. N. Menchikoff of France and the writer volunteered as interpreters for the Russian delegates both at the discussions held after the reading of various papers, and on other occasions elsewhere. In this way part of the burden was taken from the official Russian interpreter at the Congress, Miss Marianna Zavaritzkaya, daughter of the late A. N. Zavaritskii, the prominent Russian petrographer.

The fourteen Russian women who were delegates were married, but had left their husbands behind, and none of the nine male delegates were accompanied by their wives. It is interesting to note that, according to Y. Y. Gorsky, the chief of the Russian delegates, about 40 per cent of all geologists in Russia are women.

Most important among Russian papers read at the Congress was one "On the application of geology to the coal industry of the USSR" by Y. Y. Gorsky and I. I. Molchanov. It is illustrated by a map showing the distribution of the coal deposits of various ages in both European and Asiatic parts of the USSR. One of the most significant results of Soviet coal exploration in the last twenty years is a nearly three-fold extension of the previ-

ously known area of the Donetz basin (in the Ukraine), particularly to the westward, bringing the boundaries of the basin within 200-300 miles east of Kiev. An enormous area of Jurassic coal-bearing deposits, that includes high-grade coking coals, has been discovered north and east of Yakutsk in eastern Siberia.

An ambitious project of a coal survey under direction of Gorsky is to synthesize the geology of the numerous known coal basins in a way that could lead to prediction of new basins of coal and other "mineral resources," presumably oil. A monumental eight volume compendium on the "Geology of Coals deposits of the USSR" is expected to be completed and published by the opening of the XXIst International Geological Congress in 1960.

Because nearly all of the papers presented by the specialists on the Carboniferous in Germany, France, Belgium, Poland, Yugoslavia, and other countries of Europe were concerned mostly with elaboration of the geology of areas previously explored discussion of these here is limited. They will be published in the *Compte Rendu* of the Congress. Most important among these were a remarkably detailed large-scale geologic map of Yugoslavia, the report on detailed stratigraphic work on the Carboniferous done by the Australian geologists, a summary of the Carboniferous of Canada, by P. A. Hacquebard and colleagues, and tectonic profiles of the coal-bearing basins of France by K. Monomakhoff. Paleobotany of the coal-bearing strata was summarized by D. F. Stockmans of Belgium, H. Bode, W. Jessen, and K. Patteisky of Germany, and others; and some excellent large-scale photographs of spores and pollen grains by palynologists demonstrated considerable progress in this branch of paleobotany. Dr. H. Fujimoto revealed high professional skill in the study of fusulines by himself and his colleagues in Japan. Mrs. C. H. Kiragli, the only delegate from Turkey, devoted herself to absorbing useful information on techniques used in paleontology and sedimentology to be applied to geological work in her country. The most interesting paleobotanical contribution was made by Mrs. E. Plumstead of S. Africa, who flashed on the screen some of her photographs and drawings of a new kind of highly organized

vascular plant in the Gondwana flora, with fairly broad leaves carrying a peculiar combination of male and female fructification arising from their centers.

Numerous professional and social contacts of the western delegates and Russian and Polish colleagues were as cordial and delightful as could be, and did much to assure more regular exchange of scientific literature and other material, as well as scientific cooperation in the future. Duplicates of half of the publications exhibited were given to the writer to bring back to America, with a promise to send the others from Moscow and Leningrad. At a conference of H. N. Fisk, Y. Y. Gorsky and the writer, it was tentatively agreed to try to arrange for exchange lectures in 1959: Gorsky to America, for a tour of lectures on Russian geology and paleontology in English; and the writer to Russia, for lectures on some aspects of American geology and paleontology in Russian at Moscow and Leningrad. At a subsequent conference with R. W. Fairbridge, Marshall Kay and N. D. Newell, it was agreed to ask the geology department of Columbia University to be chief sponsor of Gorsky's trip. Other American geologists also have expressed interest in his coming to America. Those who attended the XVth International Geological Congress in Russia in 1938 (the late G. E. Condra, C. O. Dunbar, Marshall Kay, Norman D. Newell, Ronald De Ford, A. K. Miller) are deeply indebted to Gorsky, who together with D. V. Nalivkin (now academician of the Academy of Sciences, USSR) served as the principal companions and guides in the field excursions to the type exposures of the Permian. Recently Gorsky (and Yablokov) met some of these and other American geologists at the International Geological Congress at Mexico City, and renewed old friendships. Thus a most cordial reception of Gorsky in our country is assured.

Other Russian papers at the Congress are as follows:

Krascheninnikoff, G. F. - Fazielle Untersuchungen des kohlenführende Oberpaläozoikum.

Librovitsch, L. S., and V. D. Nalivkin. Stratigraphy of the Carboniferous of the Urals (read by title).

Miklukho-Maclay, A. D. (Miss) - Stratigraphy of Carboniferous of Central Asia (read by title).

Neuburg, M. F. (Mrs.) - Present status of the question of the age and importance for stratigraphy of the late Paleozoic Angara flora (read by title).

Novik, E. (Miss), Shulga, P. L. (Mrs.), Rotay, A. P., Aisenverg, D. E., and Miss N. E. Brazhnikova - Stratigraphy of the Carboniferous of the Donetz Basin (read by Shulga).

Petrenko, A. A. - Stratigraphy and conditions of formation of the Carboniferous coal sequence on the eastern slope of the Urals and in central Kazakhstan.

Radchenko, M. I. - Paleontological basis of the Carboniferous stratigraphy of Kazakhstan.

Ragosin, L. A. - Non-marine Carboniferous lamellibranchiata of Kuznetsk Basin (read by title).

Rausser-Chernousova, D. M. (Mrs.) - The Schwagerina beds and the upper limit of Carboniferous (read by title).

Reitlinger, E. A. (Miss) - Lower and upper limits of the early Carboniferous (read by title).

Semikhatova, S. V. (Mrs.) - Evolutionary stages in brachiopoda as a criterion for drawing stratigraphic boundaries in Carboniferous deposits (read by title).

Stepanov, D. L. - The Carboniferous and its main stratigraphic subdivisions.

Yablokov, V. S., and (Mrs.) A. P. Feofilova. - The role of alloval facies in Carboniferous deposits (Donetz, Karaganda, and Moscow basins).

A special Subcommittee on Carboniferous Stratigraphy was organized by its General Secretary, Dr. W. P. van Leckwijck, to take the place of the "Temporary Commission for the division of the Carboniferous into two sub-systems" organized at the XIXth International Geological Congress in Algiers, and which has "fulfilled its task." Following is the list of its

## INTERNATIONAL MEETING NOTES

members:

FRANCE:	P. Pruvost, G. Delepine
GREAT BRITAIN:	C. J. Stubblefield, L. R. Moore
GERMANY:	H. Bode, J. Hesemann, R. Teichmüller
GERMANY D.D.R.:	W. Remy
NETHERLANDS:	B. J. Romein, S. J. Dijkstra
USSR:	Y. Y. Gorsky, D. L. Stepanov
POLAND:	St. Stopa
CZECHOSLOVAKIA:	V. Havlena
MOROCCO:	B. Owodenko
SAHARA:	N. Menchikov
JAPAN:	H. Fujimoto, T. Kobayashi
AUSTRALIA:	K. Campbell
SOUTH AFRICA:	Mrs. E. Plumstead
CANADA:	P. A. Hacquebard
U.S.A.:	Mackenzie Gordon H. R. Wanless, M. K. Elias

At the first meeting of the Committee, Sept. 18th the following resolutions in the name of the 4th Carboniferous Congress on Carboniferous Stratigraphy and Geology were discussed and adopted:

1. The Subcommittee wishes to confirm the decisions taken at the following congresses: Bologna (1881) International Geological Congress, 1st, 2nd and 3rd Carboniferous Heerlen Congresses, Algiers (1952) International Geological Congress, namely that the Carboniferous is a system. The Subcommittee is of the opinion that the Carboniferous should remain so classified.

2. The Subcommittee further considers that the Carboniferous systems may be divided into two or three parts but that these should not be regarded as sub-systems. [Note: P. A. Hacquebard of Canada and the writer abstained from voting on this resolution because of its overly strong wording against the idea of a subdivision of the Carboniferous into two sub-systems, a proposal carried at the 3rd Congress on the Carboniferous; and they jointly submitted a minority opinion, as follows: We abstain from voting "yes" to paragraph (2) because we feel that the text

of it is too negative in rejection of the term 'sub-system for possible division of Carboniferous system. We feel that instead of saying, "should not be regarded as sub-systems," the wording should be rather, "may or may not be regarded as sub-systems." The latter term offers a compromise as regards the position of the Pennsylvanian and Mississippian of North America within the geological time-table.]

3. With a view of ensuring continuity of usage and unless any important new fact is brought forward as reason for change, the Subcommittee agrees to retain the definitions of the terms Tournaisian, Visean, Namurian and Westphalian, with their subdivisions A, B, C, etc., as adopted by previous Heerlen Carboniferous Congresses and to use these terms as standards for correlation. The lower or upper boundaries of these divisions or subdivisions should not be changed unless by such change, greater precision is attained.

4. Following resolution no. 3 the Russian members of the Subcommittee agree not to use the term Namurian in a sense different from that of the 2nd (1935) Heerlen Carboniferous Congress and they will give a new names to the division now known under the name Namurian in the USSR.

5. As the boundaries between the divisions of the Carboniferous are not the same in Western Europe and in the USSR, it is considered desirable in order to avoid confusion, to give geographical names to the Lower and to the Upper Carboniferous in Western Europe. In this respect the use of the terms Mississippian and Pennsylvanian is undesirable for Western Europe. The use of the terms Dinantian (already used in various countries) and Silesian (a new term) is suggested. [When the question was raised who is to be considered the author of the new term, van Leckwijck declined to be known as originator of the term, though he seemingly coined it] so the name, therefore, should be considered officially introduced by the Commission.

At the end of the meeting of the Commission, W.H.C. Ramsbottom and M. A. Claver submitted the following request: "For many years the goniatite name Gastrioceras subcrenatum has been used in Carboniferous stratigraphy. It acquired

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special importance at the First International Congress on Carboniferous Stratigraphy when this goniatite was taken to mark the basal fauna of the Westphalian. From recent work it appears that the specific name subcrenatum is nomenclaturally invalid. In the interests of stability of stratigraphic terms it is requested that the Subcommittee of Carboniferous Stratigraphy supports an application to be made by certain paleontologists to the International Commission on Zoological Nomenclature that the unfamiliar name Gastrioceras langenbrahmi Wedekind 1914 be suppressed in favour of Gastrioceras subcrenatum C. Schmidt 1923, which is the familiar name under which Carboniferous stratigraphers have identified the goniatite in question."

After a brief discussion, the Commission unanimously voted to support the request. A number of paleontologists, present as guests at the Committee meeting, added their signatures to the request as carried.

One of the last actions by the late Professor Jongmans in planning for the 4th Congress was the preparation of a questionnaire included with his letter of May 1957 sent to specialists on the Carboniferous of various countries of the World. After his death, the numerous answers received were published by the Organizing Committee of the Congress, and distributed in advance of the Heerlen meeting to serve as a basis for the discussions of the Congress in lieu of the synopsis of these answers which had been planned by Professor Jongmans for the Monday afternoon session of the Congress. These answers were published in a loose-leaf manner, and dated Heerlen, 1958, (distributed in May) and consist of 64 pages (the last page distributed at the time of the Congress) and 23 enclosed tables. Bibliographic validity of these contributions submitted in reply to Professor Jongman's questionnaire may be questioned. However, these documents, especially the tables, constituted valuable contributions on the Carboniferous geology, stratigraphy, and correlation, mostly never published before. They have been most helpful in that they were used and referred to by the members of the Congress and have been available to other

geologists in their current work. It seems that a proper reference to this odd publication might be worked thus:

W. J. Jongmans, et al. Answers to the questionnaire of the late Professor Jongmans: Fourth International Congress on Carboniferous Stratigraphy and Geology, Heerlen, 1958. 64 pp., 23 enclosed tables.

CONTENTS			
Contribution number		Page	Number of enclosures
1	Prof. H. Termier and G. Termier. Paris, France	1	-
2	Prof. F. Nemejc. Prague, Czechoslovakia . . . . .	3	-
3	Geological Survey of South Africa. (Dr. F. C. Truter) Pretoria, South Africa. . .	4	-
4	Prof. W. Kegel. Rio de Janeiro, Brazil . . . . .	4	-
5	Prof. P. C. Deleau. Algiers, Algeria . . . . .	5	2
6	Dr. A. Almela. Madrid, Spain	13	-
7	Geological Survey of Great Britain (Dr. J. C. Stubble- field). London, England . .	14	1
8	Prof. H. Gallwitz. Halle- Wittenberg, East Germany (joint statement of most German Stratigraphers) . .	15	2
9	Prof. Y. Y. Gorsky. Moscow, USSR . . . . .	18	1
10	Dr. Valeria Kostic-Podgorska. Belgrade, Yugoslavia . . .	20	3
11	Dr. Dorothy Hill, Brisbane, Queensland, Australia. . .	24	1
12	Dr. V. Havlena. Prague, Czechoslovakia . . . . .	28	7
13	Dr. W. R. Browne. Sydney, N.S.W., Australia . . . .	30	4
14	Prof. A. H. Voisey. New Eng- land, N.S.W., Australia. .	35	-
15	Dr. K. S. W. Campbell. New England, N.S.W., Australia	36	-
16	Dr. F. W. Booker. Sydney, N.S.W., Australia . . . .	37	-
17	Dr. D. S. Flack. Sydney, N.S.W., Australia . . . .	37	-
18	Dr. B. F. Glenister. Univers- ity of Western Australia . .	41	-
19	Dr. A. A. Opik. Canberra, Australia . . . . .	41	-
20	Dr. G. A. Thomas. Canberra, Australia . . . . .	42	-
21	Dr. J. M. Dickins. Canberra, Australia . . . . .	43	-
22	Prof. H. Yabe. Sendai, Japan	44	1
23	Dr. P. A. Hacquebard. Sydney, Sydney, Canada	55	1
24	Prof. Dr. Wehrli. Berlin, Germany . . . . .	62	-
25	Prof. A. Watznauer. Freiberg in Sachsen, Germany . . .	63	-
26	Dr. P. Guthörl. Germany . .	64	-

## INTERNATIONAL MEETING NOTES

If the answers are published again in the *Compte Rendu* (probably in 1959), it is presumed that the date of their original publication might still be considered to be May 1958.

Because the Jongmans questionnaire was not published together with the answers received, the questions asked are given here:

"1. Is the Carboniferous to be considered as a system, consisting of two subsystems or is the Carboniferous to be split up into two systems, Pennsylvanian and Mississippian; where are the limits and what is the character of these stratigraphic units?

2. The place of the different parts of the Namurian and the Autunian in this subdivision.

3. The regional subdivision accepted in your own country, the boundaries of the units, the fossils and other facts on which

these are based.

4. The possibility of a correlation of such regional subdivisions with those in other countries.

5. The possibility of replacing the limits as they are used now by other methods, for instance the introduction of a correlation based on such localities which (in zoological, botanical or lithological sense) are characteristic for the different subdivisions (type regions). (Jongmans et Pruvost, "Les subdivisions de Carbonifère continental." *Bull. Soc. Géol. de France*, (ser. 5, vol. 20, pp. 335-344, 1950).

6. The possibility of using the principal orogenic movements in establishing stratigraphical units.

It is desirable that these reports are accompanied as far as necessary by maps, sections and fossil lists."

# Reference Section

Translated Titles and Tables of Contents of Recent Russian Additions  
to the Bookshelf of the United States Geological Survey

• translated by Lydia Hartsock •

Tsytoich, N. A. [MATERIALY K 4 MEZHDURARODNOMY KONGRESSU PO MEKANIKE GRUNTOV I FUNDAMENTO-STROYENIYU] PAPERS PRESENTED AT THE FOURTH INTERNATIONAL CONFERENCE OF SOIL MECHANICS AND FOUNDATION ENGINEERING. Moscow. Akademiya Nauk SSSR, 1957, 300 copies. Price: 14 rub., 10 kop. 15 figs. USGS call no. 768.1 In81pR.

CONTENTS: Introd., p.3; Pt. I. Papers published for the Fourth International Congress of Soil Mechanics and Foundation Engineering, p. 52; Sec. 1. Types of soils and their characteristics, p. 53; Sec. 2. Methods of testing soils in the field, p. 66; Sec. 3. Foundation engineering, p.79; Sec. 4. Roads and airfield strips, p.153; Sec. 5. Pressure of soils on construction works and tunnels, p.160(?); Sec. 6. Earth dikes, dams and open pits, p. 166; Pt. II. Reports presented at the Fourth International Congress on Soil Mechanics and Foundation Engineering. Comment: Intended for engineering specialists scientists and research students.

Zenkovich, V. P. [BEREGA CHERNOGO I AZOVSKOGO MOREY] COASTS OF THE AZOV AND BLACK SEAS. Moscow. Gosudarsvennoye Izdatelstvo Geologicheskoy Literatury, 1958. 125p. 8000 copies. Price: 10 rub., 20 kop. 184 illustrations. USGS lib. call no. 521 570 Ze4.

CONTENTS: The Sea near us, p.3; The process of the development of marine coasts, p.5; Some traits of the nature of the Black and Azov Seas, p.43; Commencement of work, p.66; Northwestern coasts of the Black Sea, p.91; Dniepr area and western Crimea, p.124; The shores of the Sea of Azov, p.163; Kerchessk-Taman coasts, p.191; The southern coasts of the Crimea, p.201; Western Crimea, p.255; Practical problems, p.292; The Coast of Abkhaziya, p.309; The coasts of Adzhakiya and Kilkhidiya, p.329; Deductions, p.351; Dictionary of specialized terms, p.360; Bibliography p.364.

Comment: Solves many practical and theoretic problems not found previously in for-

iegn literature. Intended for builders of marine vessels, scientists, geologists and oceanographers.

Akademiya Nauk SSSR; Institut Geografii. [SELSKOKHOZAYSTVENNAYA EROZIYA I NOVYYE METODY EYE IZUCHENIYA] AGRICULTURAL EROSION AND NEW METHODS OF ITS STUDY Moscow, 1958, 228p.

CONTENTS: Introd., p.3; Interrelationship of the development of agriculture and the processes of erosion in the Volga Uplands (A.V. Tikhonova), p.5; The development of erosional processes in the Volga Uplands (D. L. Armand), p.76; Erosional districts in the central part of the Volga Uplands (V.P. Lidov and L. Ye Setninskaya), p.153; The investigation of water-permeability of frozen soils in the trans-Volga region (F.N. Tsykin), p.162. Methods in computing expected changes in erosion (M. L. Lvovich), p.179; Morphometric characteristics of the erosional relief (Ye. A. Mironova), p.193; Model studies of the influence of arable microrelief on the intensity of the erosion of slopes (Ye. A. Nefyedeve), p.233.

Kozygin, Yu A. [TEKTONIKANEFTENOS-NYKH OBLASTEY] THE TECTONICS OF OIL-BEARING REGIONS. Moskva, Gosudarsvennoye nauchno-technicheskoye izdatelstvo neftyanoy i gorno-toplivoy literatury, 1958. 3000 copies. Price. 24 rub., 40 kop. USGS lib. call no. 467 K838t1.

CONTENTS: Preface, p.3; Introd., p.5; Pt.1. The geological structure, p.30; Pt.2. Platform and geosynclinal areas, p.202; Pt. 3. The movement of the earth crust, p.369. Comment: Intended for professional geologists.

Shikalibeyli, Ye. Sh. [I RAZVITIYE AZER-BAYDZHANSKOY CHASTI YUZHNOGO SKLONA BOLSHOGO KAVKAZA] THE GEOLOGIC STRUCTURE AND DEVELOPMENT OF THE AZERBAIDZHAN PART OF THE SOUTHERN SLOPE IN THE BOLSHOY CAUCASUS. Baku, Akademiya Nauk

## REFERENCE SECTION

Azerbayzhansk SSR., 1956.  
Price: 12 rub., 50 kop. 60 drawings.  
USGS lib. call no. 260 57.

CONTENTS: Introd., p.5; Chap. 1. The history of investigation of Mesozoic formations of the Azerbaydzhan part of the southern slope and related areas in the Eastern Caucasus, p.7; Chap. 2. Physical geographic sketch of the territory, p.26; Chap. 3. Stratigraphy, p.36; Chap. 4. Intrusive rocks, p.132; Chap. 5. Present-day structure, p. 150; Chap. 6. The history of the geologic development, p.176; Chap. 7. Geomorphology and history of the development of the relief, p.195; Conclusion, p.216.  
Comment: The work is based on original research surveys and field work.

Filippova, M. F. [DEVONSKIYE OTLOZHENIYA TSENTRALNYKH OBLASTEY RUSSKOY PLATFORMY] DEVONIAN DEPOSITS OF THE CENTRAL REGIONS OF THE RUSSIAN PLATFORM. Leningrad, publ. by Gosudarstvennoye Nauchno-technicheskoye Izdatelstve Neftyanoy I Gornotoplivnoy Literatury, 1958. 405 p. 1600 copies.  
Price: 32 rub. 35 kop. 139 figs.  
USGS lib. call no. 335 570 F47d.

CONTENTS: Introd., p.3; Chap. 1. Brief history of the study, p.5; Chap. 2. Lithology and stratigraphy, p.16; Chap. 3. Mineralogic peculiarities of sandy-siltstone fractions of terrigenous rocks of the Zhivetskian formation and lower Shchigrosk horizon of the Franskian formation, p. 189; Chap. 4. Clayey minerals and their facies in the Stavropolsk and lower Shchigrovsk deposits on the Russian Platform, p.201; Chap. 5. Characteristics of the collecting qualities of terrigenous deposits in the Devonian of the central regions of the Russian Platform (A. A. Khanin, M. F. Afremova), p.235; Chap. 6. Geochemical investigations of the organic composition of Devonian deposits (E. D. Gimpelevich, Ye. P. Shishemian, N. P. Shneyder, and M. N. Galaktionova), p.247. Chap. 7. Characteristics of the composition of gasses in Devonian deposits, p.305. Chap. 8. Hydrochemical characteristics of terrigenous deposits of the Devonian (M. S. Karasev), p.314. Chap. 9. Facies of the Devonian basins, Paleography and Pelotectonics of the Devonian period (M. F. Filipova, S. M. Aronova, I. G. Gassanova, Z. L. Mayzel, L. I. Soko-

lova) p.329; Deductions (M. F. Filippova) p.329; Bibliography, p.395; Biliography, 395.

Comment: A summary of a large quantity of new data as well as deductions of interest to organizations and individuals carrying on geologic investigations on the Russian Platform and adjacent region.

Klushnikov, M. N. [STRATIGRAFIYA I FAUNA NIZHNETRETICHNYKH OTLOZHENIY UKRAINY] THE STRATIGRAPHY AND FAUNA OF LOWER TERTIARY DEPOSITS IN THE UKRAINE. A. N. Ukrain-skoy SSR. Kiev, Institut Geologicheskikh Nauk; Trudy, seria stratigrafii i paleontologii; issue 13, 1958. 500 copies.  
Price: 28 rub., 50 kop. 47 tables.

CONTENTS: Introd., p.5; Information on the stratigraphy of lower Tertiary deposits in the Ukraine, p.7; The Kiev formation, p.8; The Kharkov formation, p.17; Bibliography, p.28; Description of mollusk fauna, p.29; Pelecypods, p.31; Gastropods, p.204; Bibliography, p.439; Term index of species and variations, p.447; Tables illustrating same, p.455.  
Comment: Intended for commercial geologists and scientific organizations. Text-book for advanced students in geology.

Okladnikov, A. K. [MATERIALY PO STRATIGRAFII I OTNOSITELNOY KHRONOLOGII VERKHNEGO PALEOLITA SSSR] MATERIAL ON THE STRATIGRAPHY AND RELATIVE CHRONOLOGY OF THE UPPER PALEOLITHIC OF THE USSR. vol. 3. PALEOLITHIC AND NEOLITHIC. Moskva, Leningrad, Akademiya Nauk SSSR. Materialy i issledovaniya po arkheologii SSSR, 1957. 1500 copies.  
Price: 22 rub., 75 kop.  
USGS lib. call no. S 570 Sa335 no.59.

CONTENTS: From the editor, p.5; Multi-layered stations of the Kostenko-Porshevsky region on the Don river and the problem of the cultural development in the Upper Paleolithic epoch in the Russian lowlands (A. N. Rogachev), p.9; Introd., p. 9; Chap. 1. Kostenkov I., p.19; Chap.2. Telman station, p.42; Chap. 3. Station Kostenkov no. 7, p.61; Chap. 4. Station Markina Gora, p.73; Chap. 5. Station Aleksandrov, p.86; Chap. 6. Unknown multi-layered stations of Kostenkov V and Anosovka II, p.93. Chap. 7. Single one-

layered Upper Paleolithic stations Streletskaya and Gorodsovskaya, p. 97; Conclusions, p. 188; The geology of station Kostenkob-Borshevskiy region (G.I. Lazukov), p. 135; Some problems in the development of late Paleolithic cultures in the Russian lowlands (P.I. Boriskovskiy), p. 174. The telman Paleolithic settlement (P.P. Yefimenko and P.I. Boriskovskiy), p. 191; Station Sinren I and its place among paleolithic deposits of the Crimea and surrounding territories (Ye. A. Vepilova), p. 235. Comment: Based on original material.

Khimshiashvili, N.G. [VERKHNEYURSKA FAUNA GRUZI] UPPER JURASSIC FAUNA IN GEORGIA. Tiflis, publ. by Izdatelstvo Nauk Gruzinskoy SSR, 1957. USGS lib. call no. 654 570 K52.

CONTENTS: Introd., p. 3; Cephalophoda, p. 11; Lamellibranchiata, p. 84; Stratigraphy, p. 165; Upper Jurassic deposits Rachi in The vicinity of Tsets, p. 166; Village of n. Baruly, p. 173; The vicinity of villages Seva and Shromisubani, p. 175; Upper Jurassic deposits in the vicinity of villages Khristes and Khirkhonisi, p. 178; A cross-section of the village Korta, p. 179; Correlations of sections of upper Rachi multicolored bed, p. 210; Dealing with the problems of ecology of Jurassic ammonites p. 235; Soft body, p. 236; Forms of shells, p. 237; Life chamber, p. 239; Sculpture, p. 245; Distortions, p. 248; Parabolic sculptures, p. 249; Estuarine formation (?) p. 253; Evolution, p. 253; Environment and living habits of ammonite fauna in Georgia, p. 275; Tables of the stratigraphic distribution of mollusk forms, p. 281; Bibliography, p. 293.

Luppov, N.P., Drushchits, V. V. [OSNOVY PALEONTOLOGII, SPRAVOCHNIK DLYA PALEONTOLOV I GEOLOGOV SSSR] PRINCIPLES OF PALEONTOLOGY, HANDBOOK FOR PALEONTOLOGISTS AND GEOLOGISTS. Moskva, Gosudarstvennoye Nauchno-tekhnicheskoye izdatelstvo literatury po geologii i okhraneniye nedr, 1958. 6000 copies. Tables and illustrations. USGS lib. call no. 603 D55 V6.

CONTENTS: Principle stratigraphic subdivisions found in the manual "Principles of Paleontology", p. 9; Introd. (G.A. Krimgolts, N.P. Luppov), p. 11; Class Cephalopoda II, p. 13; Sub-class Ectococh-

chlia, p. 15; Super-order Ammoidea (Mesozoic), (N.P. Luppov, L.D. Kiparisova, G. Ya. Krimgolts), p. 16; Order Ceratitida (L.D. Kiparisova), p. 21; Sub-family Octocerataceae (L.D. Kiparisova), p. 21; Sub-family Hedenstroemmiaceae (Yu. N. Popov, L.D. Kiparisova), p. 24; Sub-family Melkocerataceae (L.D. Kiparisova, Yu. N. Popov), p. 26; Sub-family cerataceae (Yu. N. Popov, L.D. Kiparisova, V.N. Robinson), p. 33; Sub-family Clydonotaceae (Yu. N. Popov), p. 39; Sub-family Tropitaceae (L.D. Kiparisova), p. 44; Sub-family Lobitaceae (Yu. N. Popov), p. 47; Sub-family Araestaceae (Yu. N. Popov), p. 47; Sub-family Ptychitaceae (L.D. Kiparisova), p. 50; Sub-family Pinacocerataceae (V.N. Robinson, L.D. Kiparisova), p. 51; Order Ammonitida, Ammonites (V.V. Drushchits, N.P. Luppov), p. 52; Sub-order Phylloceratina (V.V. Drushchits), p. 53; Sub-family Phyllocerataceae (V.V. Drushchits), p. 54; Sub-order Lytoceratida (V.V. Drushchits) p. 56; Sub-family Lytocerataceae (V.V. Drushchits, N.P. Mikhaylov, A. Ye. Glazunova, p. 61; Sub-order Ammonitina (N.P. Luppov), p. 64; Sub-family Psilotacerataceae (G. Ya. Krimgolts, K. Sh. Nutsbidze), p. 64; Sub-family Eoderocerataceae (G. Ya. Krimgolts), p. 67; Sub-family Amaltheaceae (G. Ya. Krimgolts, K. Sh. Nutsbidze), p. 69; Sub-family Harpocerataceae (G. Ya. Krimgolts), p. 70; Sub-family Kosmodrataceae (G. Ye. Krimgolts, V. G. Kamysheva, Elpatyevskaya, I.P. Kakhadze), p. 79; Sub-family Haplocerataceae (G. Ya. Krimgolts, I.P. Kakhadze), p. 82; Sub-family Perisphinctaceae (N.G. Khimshiashvili, V.G. Kamysheva-Yelpatyevskaya, V.V. Drushchits, L.V. Sibirakova, N.P. Luppov, Ye. A. Troitskaya, V. P. Nikolayeva), p. 85; Sub-family Berriazellaceae (N.P. Luppov, M.S. Eristavo, V. V. Drushchits), p. 96; Sub-family Ancylocerataceae (V.V. Drushchits), p. 104; Sub-family Pulchelliaceae (V.V. Drushchits, M.S. Eristan), p. 196; Sub-family Desmocerataceae (V.V. Drushchits, N.P. Mikhaylov, M.S. Eristavi), p. 107; Sub-family Hoplitaceae (A. Ye. Glazunova, N.P. Luppov, A.A. Savelyev), p. 112; Sub-family Donvillicerataceae (N.P. Luppov), p. 116; Sub-family Acantocerataceae (A.L. Tsagareli, A. Ye. Glazunova, N.P. Luppov, A. P. Mikaylov, V.V. Drushchits), p. 124; Sub-family Engonocerataceae (N.P. Luppov), p. 128; Bibliography, p. 136; Sub-class Endochlia (G. Ya. Krimgolts) p. 145; Order

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Decapoda, p. 147; Sub-order Belemnnoidea, p. 148; Sub-order Sepioidea, p. 162; Sub-order Tentaoida, p. 168; Sub-family Prototentaoida, p. 169; Sub-family Mesotentaoida, p. 169; Sub-family Metatentaoida, p. 171; Order Octopoda, p. 171; Sub-order Palaeoctopoda, p. 172; Sub-order Cirrotentaoida, p. 172; Sub-order Polypdoidea, p. 172; Bibliography, p. 178; Appendix, p. 179; Mollusca, p. 179; Class Coniacionchia (G. P. Lyashenko), p. 180; Sub-order Tentaculoidea (G. P. Lyashenko), p. 182; Order Tentaculitida, p. 184; Order Novakiida, p. 184; Order Styliolinoida, p. 184; Sub-order Hyolithoidea (B. A. Sysoyev), p. 184; Order Hyolithida, p. 187; Order Diplotheccida, p. 188; Order Camerothecida, p. 189; Order Globorilida, p. 189; Order Hyolithelidida, p. 189; Bibliography, p. 190; Index.

Berzon, I. S. [VYSOCHASTOTNAYA SEYSMIKA] HIGH FREQUENCY SEISMIC WAVES Mosva, Akademiya Nauk SSSR, 1957. 2200 copies.

Price: 19 rub., 53 kop.

USGS lib. call no. 295 B 46.

CONTENTS: Introd., p. 3; Pt. I. Parametric measurements of the velocity of distribution of elasticity of waves in various media, p. 18; Pt. II. The study of horizontally bedded media, p. 78; Pt. III. The study of vertically bedded media, p. 163; Deductions, p. 294; Bibliography, p. 297.

Korshinskiy, D. S. [FIZIKO-KHIMICHESKIYE OSNOVY ANALIZA PARAGONEZISOV MINERALOV] PHYSICAL-CHEMICAL BASIS FOR ANALYSIS OF FORMATIONS OF MINERALS. Moscow. Izdatelstvo Akademii Nauk, SSSR. Institut Geologii, Rudnyky Mestorozhdenii, Petrografii, Mineralogii, i Geokhimii, 1957. 2000 copies.

Price: 12 rub., 30 kop. 86 illustrations.

USGS lib. call no. 118 K84t.

CONTENTS: Introd., p. 3; Chap. 1. Thermodynamic basis for the analysis of mineral formations, p. 7; 1. Survey of literature, p. 7; 2. Basic concepts of thermodynamics, p. 9; 3. Basic conditions of balance, p. 10; 4. The number of independent parameters and the law of Gibbs, p. 13; 5. Condition factors and system types, p. 17; 6. Reversed process, p. 24; 7. Thermodynamic potentials for systems of various types, p. 24; 8. Basic thermo-

dynamic interrelationship with the aid of thermodynamic potentials, p. 26; Chap. 2. Methods of describing chemical compositions, p. 42; Chap. 3. A connection between chemical and mineral composition during constant external conditions, p. 77; Chap. 4. Dependence of mineral composition on external factors, p. 103; Chap. 5. General remarks in utilizing the analysis of the formation of minerals in geology, p. 176; Bibliography.

Comment: Methods described in this work have been tested and worked by the author during a period of two decades.

Belgov, G. P. et al. [MINERALOGIYA POLIMETALICHESKIKH MESTOROZHDENIY MINERALY RUDNOGO ALTAYA. TOM 2. GALOGENIDY, OKISLY, KISLORODNYYE SOLI] THE MINERALOGY OF POLIMETALLIC DEPOSITS OF THE ALTAY MINING DISTRICT; HALIDES, OXIDES, OXY SALTS. Vol. 2. Alma-Ata, Akademiya Nauk Kazakhskoy SSSR, Alma-Ata. Institut Geologicheskikh Nauk, 1957. 2000 copies.

Price. 36 rub., 75 kop.

USGS lib. call no. 410 Ak15m t.2.

CONTENTS: Introd., p. 8; Halides, p. 12; Oxides and oxy salts, p. 39; Carbonates, p. 101; Sulfates, p. 174; Molybdates, p. 228; Phosphates, arsenites, molybdates, p. 230; Silicates (p. 234): Feldspar, p. 235, Zeolites, p. 244, Micaceous lamina, p. 327, Chlorites, p. 375.

Lazko, Ye. M. [KHRYSTALENOSNYYE KVARTSEVYYE ZHILY I IKH GENESIS] CRYSTALLINE QUARTZ VEINS AND ITS ORIGIN. Izdatelstvo Lvov Universitet, 1957. 1500 copies.

Price: 10 rub.

USGS lib. call no. 453 L45K.

CONTENTS: From the editors, p. 3; Introd., p. 4. Chap. 1. Brief geologic description, p. 6; Chap. 2. Crystalline quartz veins of Aldan, p. 18; Chap. 3. Origin of crystalline quartz veins of Aldan, p. 100; Chap. 4. Geological basis for the exploration of surveying of crystalline manifestations in the Aldan, p. 194; Bibliography, p. 200.

Comment: For exploration geologists and research scientists as well as higher institutions of learning.

Popov, G.M., Shafranovskii, I.I. [KRISTALLOGRAFIYA] CRYSTALLOGRAPHY, THIRD EDITION. Moscow, The State Scientific-Technical Publishing House of Literature for Geology and Mineral Resources, 1955.

Price: 8 rub., 45 kop. 246 figures. USGS lib. call no. 100 P8pk.

CONTENTS: Introduction to the third edition, p.3; Chap. 1. Introd., p.5; Chap. 2. The origin, age, and disintegration of crystals, p.15; Chap. 3. The symmetry of crystals, p.29; Chap. 4. Crystal forms, p.69; Chap. 5. Crystallographic symbols, p.103. Chap. 6. Types of growth and complicated forms of definite (certain?) crystals, p.132; Chap. 7. The goniometry of crystal, p.144; Chap. 8. Physical crystallography (preliminary information), p.164; Chap. 9. Fundamental studies of the structure of crystals, p.195; Chap. 10. Roentgenometry of crystals, p.216; Chap. 11. Crystallochemistry (Basic Considerations), p.245; Appendix 1, p.264; Appendix 2, p.286; Appendix 3, p.289. Comment: Apparently a textbook of crystallography.

Vikulova, M.F., et al. [METODICHESKOYE RUKOVODSTVO PO PETROGRAFO-MINERALOGICHESKOMU IZUCHENIYU GLIN] A MANUAL FOR THE STUDY OF PETROGRAPHY AND MINERALOGY. Moskva, Russian. Vsesoyuznyi Geologicheskii Institut. Ministerstvo geologii i okhrany Nedr SSSR. Gosudarstvennoye Nauchno-technicheskoye Izdatelstvo Po Geologii i Okrany Nedr, 1953. 3000 copies.

Price: 22 rub., 5 kop. 63 figs. 30 tables. USGS lib. call no. 441 R92m.

CONTENTS. Introd., p.3; Chap. 1. General characteristics of clay, p.7. Chap. 2. Methods of laboratory investigations of clays by M.F. Vikulova, p.91; Chap. 3. Petrographic analysis. (M. Fe. Vikulova, B.M. Mikhaylov, p.96; Chap. 4. Granulometric analysis. (M.F. Vikulova, Ye. I. Oreshnikova), p.110; Chap. 5. Mineralogic analyses, p.132; Chap. 6. Electromicroscopic analysis (M.F. Vikulova, B.B. Zvyagin, P.A. Shakhova, p.146; Chap. 7. Structural analysis, p.169; Chap. 8. Spectrophotometric analysis, p.229; Chap. 9. M.F. Vikulova, p.270;

Chap. 10. Chemical analysis, p.291; Chap. 11. Investigation of the changing peculiarities of clays, p.307; Chap. 12. Dialysis and electrodialysis (T.S. Berlin), p.327. Chap. 13. Infra-red spectral analysis of clayey minerals (O.N. Setkina), p.334; Chap. 14. Examples of clay analysis by various methods, p.345.

Tatarsky, V.B., ed. [SPRAVACHNOYE RUKOVODSTVO PO PETROGRAFI OSADOCHNYKH POROD] MANUAL OF THE PETROGRAPHY OF SEDIMENTARY ROCKS. Leningrad, publ. gosudarsvennoye nauchno-technicheskoye izdatelstvo neftyanoy i gornotoplivnoy literatury, 1958. 12,700 copies. Price: 24 rub. 10 kop. USGS lib. call no. 180 Sp7.

CONTENTS: Introd., p.5; Chap. 1. General information on sedimentary rocks, p.7; Chap. 2. Classification of sedimentary rocks, p.15; Chap. 3. Distribution and composition of sedimentary rocks, p.20; Chap. 4. Weathering, re-distribution and deposition of material, p.40; Chap. 5. Transformation of sediments and sedimentary rocks, p.62; Chap. 6. General laws in the formation of sedimentary rocks. Facies and formation, p.79. Chap. 7. Texture of sedimentary rocks, p.95; Chap. 8. Physical characteristics of rocks, p.130; Chap. 9. Geophysical methods of investigating rocks in boreholes, p.170; Chap. 10. Minerals of sedimentary rocks, p.190; Chap. 11. Mineral remains of rock-forming organisms, p.415; Chap. 12. Organic components of coals, coal-rocks and inflammable shales, p.463; Subject Index, p.475; Index of Latin terms, p.484. Comment: For geologists dealing with petrography, sedimentary rocks and doing surveys in sedimentary rock.

Bliznyak, Y.V. [VODNOENERGETICHESKIYE IZYSKANIYE] WATER-POWER EXPLORATION Leningrad, Gosudarsvennoye Energeticheskoye Izdatelstvo, 1957. USGS lib. call no. 785 B6lv.

CONTENTS: Introd., p.3; Pt. I. Chap. 1. The problems of water-power exploration. The brief history of water exploration in the USSR, p.5; Chap. 2. The connection of exploration and planning, p.8; Pt. II. Geodesy. Geodesy and topographic works. Chap. 3. General information on geology,

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- p. 14; Chap. 4. The system of coordinates, p. 293. Pt. VI. Chap. 44. Organization and prospects for water-power exploration, p. 300. Chap. 45. Prospects for water-power research and its utilization, p. 310. Comment: Intended for higher institutions of learning dealing with electric power hydrotechniques, and construction engineering.
- p. 16; Chap. 5. Scales of maps, their nomenclature and legends, p. 21; Chap. 6. Relief in maps and plans, p. 26; Chap. 7. Projection plans, p. 32; Chap. 8. Basic rules of technical computation, p. 37; Chap. 9. Basic information on the mistakes of the theory of computation (?), p. 38; Chap. 10. Legends and measurement lines, p. 42; Chap. 11. The simplest geodetic instruments, p. 48; Chap. 12. Theodolites. Range-finders, theodolite operations, p. 52; Chap. 13. Planned supporting net, p. 69; Chap. 14. Grading, p. 74; Chap. 15. Plane tabling, p. 94; Chap. 16. Tacometric survey, p. 100; Chap. 17. The concept of land and air stereophoto surveys, p. 102; Chap. 18. Semi-instrumental (?) surveys, p. 107; Chap. 19. Determining the areas according to maps, p. 108; Chap. 20. Engineering geodetic works in the planning of hydrostation installations, p. 111; Chap. 21. Measuring surveys, p. 116; Chap. 22. The most important documents on topographic geodetic and measuring works, p. 127; Pt. III. Hydrologic and meteorologic works Chap. 23. General information on hydrologic works, p. 130; Chap. 24. Observations on the fluctuations of the water-level. Computation of the average level, p. 132. Chap. 25. Determining the velocity of the current and the expenditure of water, p. 140; Chap. 26. Observations on the flow. Determining the head flow, p. 168; Chap. 27. Temperatures, freezing, winter conditions, the opening of rivers and ice flow, p. 178. Chap. 28. Documents on hydrological works, p. 188; Pt. IV. Geologic Investigations. Chap. 30. General information on geology, p. 200; Chap. 31. Minerals and rocks, p. 202; Chap. 32. The history of the earth and the activity of internal and external forces, p. 215; Chap. 33. Geomorphology, p. 230; Chap. 34. Hydrogeology; Chap. 35. Engineering-geologic investigations, p. 239; Chap. 36. Geologic and geomorphologic information, p. 241; Chap. 37. Geologic surveys, p. 248; Chap. 38. Hydrologic investigations, p. 258; Chap. 39. The physical-mechanical characteristics of mineral deposits, p. 265; Chap. 40. Engineering-geologic mapping, p. 274; Chap. 41. Peculiarities of the engineering-geologic research of hydro nets and other hydrotechnical structures, p. 279; Pt. V. Various exploration works. Chap. 42. Soils, geobotanical, hydrochemical, and hydrobiological investigation,
- Gosdarstvennyy Gidrologicheskiy Institut. [TRUDY GOSUDARSTVENNOGO ORDENA TRUDOVOGO KRASNOGO ZNAMENI GIDROLOGICHESKOGO INSTITUTA] THE STUDY OF THE PROCESSES OF FLOODS AND METHODS OF HYDROLOGIC COMPUTATIONS. Issue 48, Leningrad, Gidrologicheskoye Izdatelstvo, 1953. 800 copies. USGS lib. call no. 780 570 R92F, issue 38 92.
- CONTENTS: Computation of probable maximum expenditures of water and the scope of snow and rain water floods. The methods of calculating gas in water (G.A. Alekseyev), p. 3; The methods of calculating gas in water (V.G. Andreyanov), p. 66; Peculiarities of the hydrologic regime of the lakes in the Barabinsk depression (S. Yu. Belinkov), p. 168; Dealing with hydrologic computations during the planning of irrigational systems in the Barabansk depression (S.I. Kharchenko), p. 174; Methods of computing the maximum flow of spring waters in the Barabinsk depression (N.F. Panova) p. 182; The various fluctuations of waters in the rivers of the USSR (P.S. Kuzin), p. 188; Investigating the processes of the formation of flows of melted waters (A.G. Kovzel), p. 216.
- Gosudarstvennyy Gidrologicheskiy Institut. [VOPROSY METODIKI, NABLYUDENIY NAD ISPARENIYEM, VLAZHNOSTYU POCHVY SNEZHNYM POKROVOM] PROBLEMS OF METHODS OF OBSERVATION ON EVAPORATION, HUMIDITY OF SOILS, AND SNOW MANTLE. Leningrad, Gidrometeorologicheskoye Izdatelstvo, 1954. USGS lib. call no. 780 570 R92t, issue 45. 99.
- CONTENTS: Investigation of methods of evaporation from soils (V.F. Pushkarev) p. 5; The computation of total evaporation with the aid of evaporators (A.R. Konstantinov and L.R. Strezer), p. 66; The correlation of various methods to determine

evaporation (A.R. Konstantinov), p.95. Experience in utilizing hydraulic soil evaporators of a small scale (FPI-51) (S.F. Fedorov), p.121; Regarding the transitional coefficients of land evaporators (V.I. Kuznetsov) ; The influence on the indicators of water evaporators, their size, and the soils in which they are installed (P.A. Uryvayev), p.157; The investigation of the influence of warmth isolation on indicators of water evaporators (V.I. Kuznetsov), p.173; Experience in utilizing the flotating evaporating device (T.G. Fedorova, and A.R. Konstantinova), p.182; Observations of humidity of soils on water stations in hilly mountainous terrain (I.S. Shpak, p.196; On the accuracy of observations of the snow cover mantle during snow surveys (I.S. Shpak), p.233.

Konstantinova, A.R., Kuprinova, V.V. [EKSPERIMENTALNYE ISSLEDONVANIYA ELEMENTOV VODNOGO BALANSA NA VALDAYE] EXPERIMENTAL INVESTIGATIONS OF THE WATER EQUILIBRIUM IN THE VALDAY. Leningrad, Hydrometeorological Publishing House, 1957. Price: 15 rub., 3 tables, 9 illustrations, and appendix. USGS lib. call no. 780 57 R92t.

CONTENTS: Experimental investigations of the factors of spring flow (P.A. Uryvayev), p.5; Evaporation in Forests (S.F. Fedorov), p.74; Twenty-four hour cycle of total evaporation from meadows and its connection with meteorological factors (M.P. Kozlov), p.134; Experience of the utilization of precipitation measurements for the calculation of the volume and distribution of snowfall in the Valday (N.A. Zykov), p.172; Means for determining the coefficient of reflection of melting snow according to change in its surface condition (M.I. Novikova), p.183; Results of experimental investigations of melting snow in fir tree forests (A.Ya. Oiya), p.199. Comment: Intended primarily for hydrologic engineers and meteorologists. Contains some original data.

Makerov, Yu. V. [ANTARKTIKA . OSNOVNYE CHERTY GIDROGICHESKOGO REZHIMA ANTARKTICHESKIKH VOD ANTARCTICA] Pt. 11. BASIC TRAITS OF THE HYDRAULIC REGIME OF ANTARCTIC WATERS. Moskva-Leningrad, Gosudarsvennyi Okeanograficheskii Insti-

tut, Gidrometereologicheskoye Izdatelstvo, 1956. 1000 copies. Price: 6 rub., 30 kop. 18 illustrations. USGS lib. call no. 530.9 M85a.

CONTENTS: Preface, p.5; Introd., p.4, Chap. 1. General hydrologic characteristics, p.12; 1. Boundary of Antarctic waters. Distribution of land and water, p.12; 2. Depth of marine bottom relief, p.14; 3. Factors influencing the distribution of hydrologic characteristics, p.16; 4. The distribution of hydrologic characteristics in space, p.20; 5. Changes in hydrologic characteristics in time, p.30; 6. The circulation of waters, p.37. Chap. 2. Water types in the Antarctic regions, p.41; 1. Factors determining the water types, p.41; 2. Water types in the Antarctic region, p.43; 3. Surface Antarctic waters p.51; 4. Depth of waters, p.65; 5. Natural Antarctic waters, p.76; Chap. 3. Antarctic water types, p.87; 1. Marine ice, p.87; 2. Terrestrial ice, p.96; Deductions, p.101; Bibliography, p.102; Appendix. Hydrologic cross section, p.105. Comment: Intended for specialists connected with investigations of Antarctic waters, the whale industry, and marine navigation. May be worth further investigation for possible translation.

Bardin, I.P. [ZHELEZNORUDNAYA BAZA CHERNOY METALLURGII SSSR] IRON ORE BASIS OF FERROUS METALLURGY. Moscow. Publ. Akademiya Nauk, SSR. Mezhdomstvennaya Postoyannaya Komisiya Zhelezu, 1957. 4000 copies. Price: 32 rub., 40 kop. 11 figs. 94 tables. USGS lib. call no. 433 570 Ak1352.

CONTENTS: Preface, p.3; Introd., p.7; Pt. 1. Genesis of iron ores and general evaluation of the conditions of iron ore basis in the SSSR, p.17; Pt. 2. Brief geologic industrial characteristics of iron ore deposits in the SSSR, p.65; Sec. 2. Characteristics of the iron ore deposits of western and southern SSSR, p.79. Sec. 3. Iron ore deposits of the eastern SSSR, p.179; Pt. 3. Possible prospects for the utilization of iron ore basis of ferrous metallurgy in the SSSR. Sec. 1. The development of distribution of ferrous metallurgy in the SSSR in 1956, p.379; Sec. 2. Development of the iron-ore industry in the SSSR during the post-war period, p.410; Sec. 3. Industrial evalu-

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ation of iron ore deposits in the SSSR and selection of basis for the construction of plants of ferrous metallurgy, p.433; Sec. 4. Perspective of the development of iron-ore basis of ferrous metallurgy in the SSSR, p.473; Sec. 5. Index of the exploration and development of ores in the SSSR, p.542; Comment: The development of ferrous metallurgy in the SSSR during the past twenty years.

Botvinskina, L.N., Zhemchuzhnikov, Yu. A. [ATLAS LITOGENERICHESKIKH TIPOV UGLENOSNYKH OTLOZHENIY SREDNEGO KARBONA DONETSKOGO BASSEINA] ATLAS OF ROCK TYPES OF THE COAL DEPOSITS IN THE MIDDLE CARBONIFEROUS OF THE DON BASIN. Moscow. Akademiya Nauk, SSR. Institut Geologicheskikh Nauk, 1956. 3000 copies.

Price: 23, rub., 40 kop. 106 tables.

CONTENTS: Chap. 1. General information, p.3; Chap. 2. Continental deposits, p.35; Chap. 3. Transitional deposits from Continental to Marine, p.68; Chap. 4. Marine deposits, p.102.

Comment: Concrete material for a correct geologic evaluation.

Gosgeoltekhizdat. [RADIOMETRICHESKIYE METODY POISKOV RAZVEDKI URANOVYKY RUD] RADIOMETRIC METHODS OF PROSPECTING AND SURVEYING FOR URANIUM ORE. Ministerstvo Geologii i Okhrany Nedr SSR. Gosudarsvennoye Nauchno-Technicheskoye Izdatelstvo Literatury Po Geologii i Okhra ne Nedr. Price: 4 rub., 35 kop. 196 figures. USGS lib. call no. 439 R12.

CONTENTS: Introd., p.3; Pt. I. Physical and Geological Basis for methods of prospecting radiometry, p.7; Chap. 2. Radiometric radiations and their interrelationship with substances, p.55; Chap. 3. Radioactivity of the earth's crust, p.108; Chap. 4. The geochemistry of uranium and thorium. Pt. II. Methods of measurement and apparatus. Chap. 5. Ionization method, p. 177; Chap. 6. Impulse method, p.194; Chap. 7. Radiometric apparatus, p.222; Chap. 8. Evaluation and work in radiometric measurements, p.261; Chap. 9. Laboratory methods of radioactive measurements, p.279; Pt. III. Chap. 10. Prospecting and surveying methods. Aerogamma prospecting for

uranium, p.364; Chap. 11. Field gamma deposits survey. Chap. 12. Field emanation method, p. 406; Chap. 13. Uranometric survey, p.463; Chap. 14. Gamma core sampling by electrical means, p.484; Chap. 15. Radiometric sampling of uranium ores in natural condition, p.528; Pt. IV. Complex geophysical methods and factors, determining their effectiveness during exploration and surveying of uranium deposits. Chap. 16. Basic factors determining the effectiveness of geophysical methods in prospecting and surveying of uranium ores, p.550; Chap. 17. The complex application of geophysical methods in prospecting and surveying of uranium deposits, p.565. Comment: May very well contain information on new techniques.

Gostopkhizdat. [SPRAVOCHNIK GEOLOGA PO PRIRODNOMY GAZU] A HANDBOOK FOR GEOLOGISTS ON NATURAL GAS, Vol. 3. Moskva, Gosudarsvennoye Nauchno-technicheskoye izdatelstvo neftyanoy i gornotoplivoy literatury, 1955. 7000 copies. Price: 26 rub., 25 kop. 415 figs., 12 tables. USGS lib. call no. 467 Sp7 t.3.

CONTENTS: Chap. 1. Topographic geodetic works, p.7; Chap. 2. Geologic surveys, 103; Chap. 3. Hydrogeology, p.320; Chap. 4. Mining, p.394; Chap. 5. Map boring, p.442; Chap. 6. Structural boring, p.442; Chap. 7. Geochemical methods of prospecting, p.502; Chap. 8. Gravity surveys, p.540; Chap. 9. Magnetic surveys, p.558; Chap. 10. Electro-surveys, p.579; Chap. 11. Seismic surveys, p.635; Chap. 12. Geologic evaluation of prospects in petroleum and gas, p.659; Chap. 13. Safety techniques and geologic surveys in fireproof bore-hole operations, p. 669. Comment. Handbook for oil and gas geologists.

Akademiya Nauk SSSR. [D.I. MENDELEYEV I RUSSKOYE NEFTYANNOYE DELO] D.I. MENDELEYEV AND THE RUSSIAN PETROLEUM INDUSTRY. Moskva, Institut Yestestvoznaniya i Tektoniki. (Institute of Natural Sciences and Tectonics) Akademiya Nauk SSSR, 1957. 3000 copies. Price: 18 rub., 48 figures. USGS lib. call no. 467 570 P22.

CONTENTS: Introd., p.3; Chap. 1. The development of the petroleum industry up to 1860, p.9; Chap. 2. The first innovator's hypothesis (?) of D.I. Mendeleyev, p.13; Chap. 3. The struggle of D.I. Mendeleyev for change in the leasing system and tax, in the petroleum industry in Russia, p.36; Chap. 4. The familiarization of A.I. Mendeleyev with the petroleum industry in Russia, p.53; Chap. 5. The problem in creating a large petroleum industry (70-80 years), p.62; Chap. 6. Mendeleyev's contribution to the technique of petroleum lubricating oils (the end of the seventies and beginning of the eighties) p. 71; Chap. 7. The investigation of American and Russian oils, p.99; Chap. 8. The perfecting of the factory techniques in the refining of petroleum, p. 112; Chap. 9. Investigation and proposals in the field of refining of petroleum and the classification of coal, p. 127; Chap. 10. The works of Mendeleyev in contributing to the industry of heavy illuminating oils and their use, p.142; Chap. 11. Regarding the complete and efficient utilization of petroleum, p.156, Chap. 12. Perfecting the quality of kerosene p.177; Chap. 13. Regarding the proposal in the construction of the Baku-Batum petroleum conductors. Chap. 14. The struggle of D.I. Mendeleyev against rumors of the depletion of the Baku petroleum deposits, p. 223; Chap. 15. Regarding taxes for petroleum and petroleum products, p.233. Conclusion. A chronicle of the life and activity of D.I. Mendeleyev in the scientific field of petroleum and the petroleum industry, p.246; Appendix, p.255; Bibliography, p.256; Index of names, p.264.

Comment: Should be interesting from the historical standpoint.

Altsovskiy, Ye., Kuznetsova, A.I.  
[OBRAZOVANIYE NEFTI I FORMIROVANIYE NEFTYANNYKH ZALEZHEY]  
THE FORMATION OF PETROLEUM AND PETROLEUM DEPOSITS. Moskva, Izdatelstvo neftyanoy i gorno-toplivnoy literatury, 1958. 2000 copies.  
Price: 7 rub., 10 kop. 29 tables.  
USGS lib. call no. H 67 A170.

CONTENTS: Introd., Pt. 1. General problems on the origin of petroleum, p.3; Chap. 1. Primary substances, p. 18; Chap. 2. Petroleum forming beds, p.36; Chap. 3. Processes of the formation of

petroleum in underground water, p.53; Chap. 4. The mechanism of the formation of petroleum deposits, p.99; Pt. 2. Preliminary results of the survey in the Groznessk Dagestan petroleum region. Chap. 5. Brief survey of hydrogeologic conditions of the Groznessk-Dagestan region and the content of organic substances in underground waters, p. 119; Chap. 6. Results of microbiologic investigations, p.145; Comment: Describe a new hypothesis on the formation of petroleum. Intended for geologists and hydrogeologists working in the field of petroleum geology.

Akademiya Nauk SSSR, Geologicheskii Institut. [OCHERKI PO ISTORII GEOLOGICHESKIKH ZNANIY] ESSAYS ON THE HISTORY OF GEOLOGICAL SCIENCES. Moscow. 1958. 3000 copies.  
Price: 11 rub., 40 kop.  
USGS lib. call no. 207 (570) Ak6 no.6.

CONTENT: N.I. Nikolayev. 1. The history of the development of basic concepts in geomorphology. Geomorphology abroad, p.3; 2. The development of geomorphologic concepts in Russia, p.40; 3. Basic stages of the development of geomorphologic concepts, p.84; 4. Bibliography, p.88. M.S. Shvetsov. Materials on the history of the development of the science of sedimentary rocks in the USSR p.97; Introd., p.97; The Precambrian Period, p. 100; II. The petrography of sedimentary rocks as an independent science, p. 108; III. Trends in science on sedimentary rocks in the Soviet Union; origin, success, and present-day conditions, p.168; IV. Problems of general theory concerning the formation of sedimentary rocks in the works of Russian and Soviet scientists, p. 198; V. Bibliography, p. 217; Tables and illustrations.

Akademiya Nauk SSR, Institute Geografii. [MATERIALY PO BIOGEOGRAFIY SSSR. ZOOGEOGRAFIYA I EKOLOGIYA NAZEMNOY FAUNY KAZAKHSTANA] MATERIALS ON BIOGEOGRAPHY IN THE USSR. ZOOGEOGRAPHY AND ECOLOGY OF LAND FAUNA OF KAZAKHSTAN. Moscow, 1953, issue 54. 1500 copies.  
Price: 27 rub., 40 kop.  
USGA lib. call no. G570 Acl22g.

CONTENTS: Introd., p.3; A brief description of the itinerary and conditions en-

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countered in the work of the biogeographic expedition in 1947 and 1948 (A.N. Formozov) p. 5; The fauna of horseflies in Central Kazakhstan (N.G. Obsufiev and A.N. Formozov) p. 12; Life forms of rodents in the plains of Kazakhstan and some laws governing their geographic distribution (K.S. Khodashova), p. 33; Materials on the ecology of water pulevki (?) of northern Kazakhstan (K.S. Khodashova and L.A. Gibet) p. 195; The geographic distribution of birds of prey in the plains of Kazakhstan and their importance in destroying vermin (V.I. Osmolovskaya), p. 219; The extermination of migrating locusts by birds in the seven lake region in the Kustanaysk region (A.M. Cheltsov-Bebutov), p. 308; The number of some field animals of Central Kazakhstan according to data from a study of trapped birds of prey (A.N. Formozov and B.I. Osmolovskaya), p. 329; Ecologic description of the steppe, and the grey woodchuck (R.P. Zimina), p. 351; Amphibia and reptilia of southeastern Turgay and the northern Urals (L.G. Dinesman), p. 383; Observations on reptiles of Central Kazakhstan along the Dzhulek-Atbasa village road (A.M. Cheltsov-Bebutov), p. 423. Comment: Based on field investigations; has new information on the geographic distribution of some animal groups of Kazakhstan.

Akademia Nauk SSSR., Kola branch. [VOPROSY GEOLOGII I MINERALOGII KOLSKOGO POLUOSTROVA] PROBLEMS OF GEOLOGY AND MINERALOGY OF THE KOLA PENINSULA. Moskva-Leningrad, Kolskiy filial imeni S.M. Kirova. Izdatel'stvo Akademii Nauk SSSR, 1958. 3000 copies. Price. 11 rub., 95 kop. USGS lib. call no. 203 570 V89.

CONTENTS: From the editor, p. 3; Deals with some debatable questions on the geologic structure of the Sopnayvench Massif in the Moncha-tundra (E.K. Kozlov), p. 7; Kukisvumcharr-Inkspor nepheline-apatite body (T.N. Ivanova), p. 25; Regarding the metamorphism of basic rocks and contact manifestations in the region of the lower and middle course of the Iokanga River (B.A. Indin), p. 95; Granophyritic rocks and gneiss quartz-metakerophyre sequences of Imandra-Varguga on the Kola Peninsula, (L.A. Kazyuk) p. 111; Yttrium mineralization of amazonite pegmatites in fissured granites of the Kola Peninsula

(E.V. Belkov), p. 126; New data on the mineralogy of Inkspor in the Khibian tundras (M.D. Dorfman), p. 146; Lovehorite-bearing veins of the eastern part of Yevselogchorr mountain in Khibin (A. V. Galakhov). Copper-nickel deposits of Ortayva in the Pecheng region (G.I. Gorbunov), p. 181.

Boitova, E.P. et al. [GEOLOGIYA IUGO-ZAPADNOY CHASTI TURGAISKOGO PRO-GIBA] GEOLOGY OF THE SOUTH-WESTERN PART OF THE TURGAY DEPRESSION. The All-Union Scientific Research Geological Institute. Vsesoyuznyy Nauchno-Isslepo vatelskii Geologicheskii Institut. Moscow, Trudy N.S. t. 5. Gosudarsvennoie Nauchno-Technicheskoye Izdatelstvo Literaturny po Okhrane Nedr. The State Scientific-Technical Publishing House for Literature in Geology and Mineral Resources, 1955. 1500 copies. Price: 10 rub., 35 kop. USGS lib. call no. 570 Tc2 n.s.t.5.

CONTENTS: 1. Introd., (N.K. Ovechkin) p. 6; 2. Brief physical-geographic description (N.K. Ovechkin). 3. The history of the study of the Turgay depression (N.K. Ovechkin) p. 11; 4. Stratigraphy (E.A. Mazina), p. 21; 5. Results of mineralogic petrographic investigations of clayey fractions of some types of rocks of the Mesozoic and Cenozoic ages (B.M. Mikhaylov) p. 126; 6. Basic information regarding the tectonics of the region (N.K. Ovechkin) 7. Some data on the history of the geologic development (E.P. Boytseva and N. K. Ovechkin), p. 147; Appendix, p. 157; Bibliography, p. 158.

Fedorov, Ye. Ye., Baranov, A.I. [KLIMAT RAVNINY YEVROPEYSKOI CHASTI SSSR V POGODAKH] LOWLAND CLIMATE IN THE EUROPEAN PART OF RUSSIA. Moscow-Leningrad, Trudy... issue 45. Akademia Nauk SSSR publishing house, 1949. Price: 28 rub., 50 kop. 90 figs, 178 tables. USGS lib. G 570 Ac122 G3.

CONTENTS: Preface, p. 3; Introd., p. 5; Sec. 1. Principal physical factors influencing the weather in the lowlands (plains) of the Russian part of the USSR, p. 9; Sec. 2. Weather in the lowland, its origin and laws governing its distribution in the entire territory, p. 100; Sec. 3. Climate in various regions of the lowland, p. 220; Appendix 1-4,

p.401; Bibliography, p.405.

Comment: A regional climatological survey, based on previous works.

Golubeva, Z.S., Koloshina, O.V. [POSOBIE K LABORATORNO-PRAKTICHESKIM ZANIATIAM PO GEODEZU] MANUAL FOR LABORATORY WORK IN GEODESY. Moscow. The State Publishing House of Literature for Agriculture, 1957. 8000 copies. 88 illustrations. USGS lib. call no. 740 G58P.

CONTENTS: Introd., p.3; Sec. 1. Practical winter works, p.5; Sec. 2. Practical field works.

Comment: A textbook on Geodesy.

Markov, K.K. [PUTESHEVSTVIYE V ANTARKTIKU] VOYAGE INTO THE ANTARCTIC. Moskva. Publ. by Izdatelstvo Moskovskogo Universiteta, 1957. 1000 copies.

Price 16 rub., 40 kop. Illustrations. USGS lib. call no. 596 990 M34p.

CONTENTS: To the reader, p.5; Introd., p.7; Chap. 1. Voyage into the Antarctic, p.27; Chap. 2. Antarctic, p.78; Chap. 3. The return, p.179;

Comment: Private observations and experience of the author.

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